EXPLORATION OF THE IMPACT OF THE LONG-TERM EXPOSURE TO AIRCRAFT CABIN NOISE ON PILOT STAFF

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Abstract:

Due to the increasing human exposure to low frequency and high-intensity (greater than 110 dB SPL) noise, which is typical for the working environment of civil pilots, a negative impact on their health have been noticed. Because of prolonged exposure to combined influence of noise and vibrations pilots can suffer from a chronic progressive cumulative disease - VAD, Vibroacoustic disease. Symptoms are numerous: mood changes, respiratory tract infections, bronchitis, heartburn, chest pain, nausea, skin infections, conjunctivitis, blood in the urine, gastritis, bleeding nose, varicose veins, etc. Disease was first diagnosed in the 1984 with the airline technicians and military pilots in the 1992 and seven years later with the civil pilots and cabin crew. The paper will deal with the subjective assessment of respondents' own state regarding hearing and symptoms that can be associated with vibroacoustic disease. The study was conducted on a sample of civil pilots with more than three years long service. Correlations in auditory effects of noise, temporary threshold shift, tinnitus and vibroacoustic disease symptoms were compared with the length of service and type of aircraft which the respondents were flying on.

Keywords: civil pilot, working age, noise, subjective disturbances, TTS, PTS, tinnitus, vibroacoustic disease

1. INTRODUCTION

In common use, the word noise means any unwanted sound. Sounds, particularly loud ones, that disturb people or make it difficult to hear desired sounds, are noise. Aircraft noise is noise produced by any aircraft or its components, during various phases of flight: on the ground while parked and connected to external power sources such as ground power units, while taxiing, on run-up from propeller and jet exhaust, during take-off, underneath and lateral to departure and arrival paths, over-flying while en route, or during landing. Questionnaire research on a sample of more than 30 civil pilots with more than three years long service was conducted in this paper.

2. EFFECTS OF NOISE ON PEOPLE

Noise affects both health (physical and psychological) and behavior. The effects of noise on human hearing are well assumed, but the effects of noise on other aspects of human health are less understood. Noise can cause annoyance and aggression, high stress levels, skin infection, respiratory tract infections, tinnitus, hearing loss, mental and neurological disorders etc.
Pilot staff are exposed to significant noisy environment which can result in appearance of vibroacoustic disease symptoms, tinnitus, temporary threshold shift (*TTS*), permanent threshold shift (*PTS*) and compromise speech intelligibility between drivers staff.
Vibroacoustic disease *(VAD)* is a chronic, progressive, cumulative, systemic disease. Studies have shown that environments with high-intensity sound over 110 dB, coupled with low-frequency sounds below 100 Hz, place people at high risk for developing VAD. Disease was first diagnosed in the 1984 with the airline technicians and military pilots in the 1992 and seven years later with the civil pilots and cabin crew [2].
According to Alves-Pereira and Branco [3], the stages of VAD are as follows:
Stage 1 - MILD (1-4 years of exposure to noise): Slight mood swings, indigestion, heartburn, mouth/throat infections, bronchitis;
Stage 2 - MODERATE (4-10 years of exposure to noise): Chest pain, definite mood swings, back pain, fatigue, skin infections (fungal, viral, and parasitic), inflammation of stomach lining, pain and blood in urine, conjunctivitis, allergies;
Stage 3 - SEVERE (> 10 years of exposure to noise): psychiatric disturbances, hemorrhages (nasal, digestive, conjunctive mucosa) varicose veins, hemorrhoids, duodenal ulcers, spastic colitis, headaches, severe joint pain, intense muscular pain, neurological disturbances.
Pilot staffs are also prone to tinnitus, which is not a disease, but a condition induced by exposure to noise and it expresses itself as an ear buzzing. Main cause of tinnitus is noise exposure which damages hair cells in the inner ear.
Auditory fatigue is defined as a temporary loss of hearing after exposure to sound. This results in a temporary shift of the auditory threshold known as a temporary threshold shift *(TTS)*. Short exposure to noise of about 80 dB SPL results with TTS of about 1 minute. TTS of 8 hours is result of sufficiently long exposure to noise and can be physiological fatigue with appearance of tinnitus in the beginning, recovery takes about 16 hour. TTS of longer duration is pathological fatigue, and recovery is linear by few dB per day. The damage can become permanent – PTS (permanent threshold shift) if sufficient recovery time is not allowed before another sound exposure takes place.
Syllable intelligibility is the percentage of speech that a listener can understand or the clarity of a speaker's utterances. Aircraft cockpit can be congested with different kind of noise and sound of aircraft information systems which can decrease intelligibility between pilot staff and it can result in deterioration of flight safety.

3. CABIN NOISE SOURCES

Cabin noise is combination of different sound sources and it is generally divided into engine noise, noise associated with the airframe itself – structure borne noise, and noise that is associated with onboard aircraft systems, such as APU and air condition noise while on apron. Sources and paths of airborne and structure-borne noise resulting in interior noise are shown at Figure 1. Also, there can be some other sounds produced by

sound annunciators from different aircraft systems (i.e. safety systems, failure warning system or imminent danger warning system).

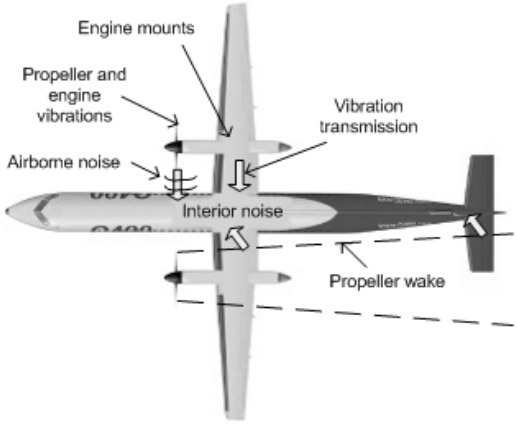

Fig. 1: Sources and paths of airborne and structure borne noise resulting in interior noise

Engine noise is significantly more noticeable than aerodynamic noise, and its spectrum is highly dependent on the type of engines. The main types of aircraft engine are piston, turbojet, turbofan and turboprop. Unlike turbofan noise spectrum, which is dominated by high frequency broadband noise, turboprop noise spectrum is dominated by a few distinctive low frequency tones which can differently affects the human subjective assessment. The spectra of turbofan and turboprop noise are in detail shown in [1].
Cabin noise is also dependent on flight regime; for example:

- Take-off – noise is dominantly due to high engine power settings
- Cruising – noise is result of joint action of airborne and structure borne noise, mostly due to engine noise and aerodynamic airflow
- Landing approach – noise is created by aerodynamic airflow over the landing gear, flaps, landing gear cavity storage, air brakes
- Touchdown – noise is created by wheel friction and impact on runway
- Roll-off – noise is created by wheels rolling, high power settings and vibrations from thrust reversers

4. THE RESEARCH QUESTIONS AND THE RESULTS

In order to explore the impact of the long-term exposure to aircraft cabin noise of pilot staff for this paper, a survey was carried out. The study was conducted on a large number of respondents with more than five years long experience from different airlines, who completed a six-question survey. First two questions should have been filled with personal data, types of aircrafts, the number of flight hours and years spent on each aircraft during their employment. The third question referred to the effect of different types of noise in the cockpit on flight safety. Respondents should have to rate generally from 1 to 5 (1-no influence, 5 - maximum effect) different noise sources. Fourth question referred to any disturbances that respondents feel after work shift (TTS, Tinnitus or Syllable intelligibility problem). Vibroacoustic symptoms should have been

marked in the fifth question. In the last question pilots should have to note down if flight safety has been compromised in their work experience due to the high level of noise in the cockpit. The research results are presented at the figures and tables below.

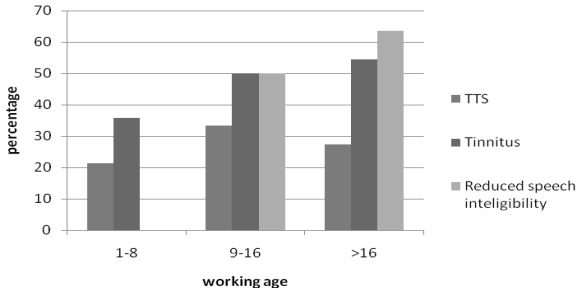

Figure 1. Percentage of the audible noise disturbances in relation to the pilots working age

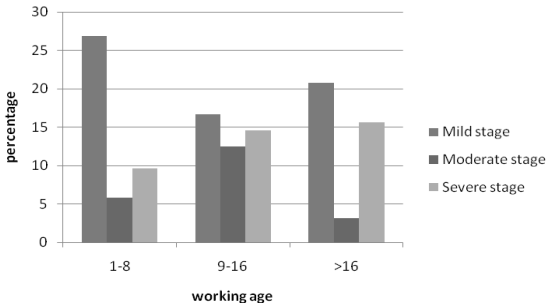

Figure 2. Percentage of the symptoms occurrence according to the VAD stages in relation to the pilots working age

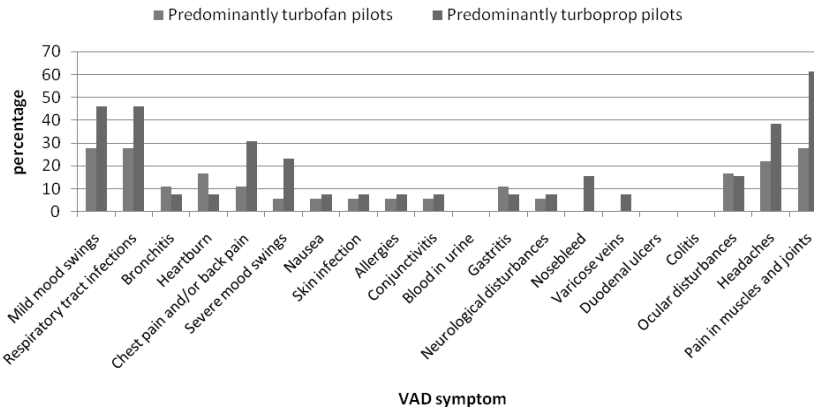

Figure 3. Percentage of the VAD symptoms occurrence according to the prevalent type of aircraft flown

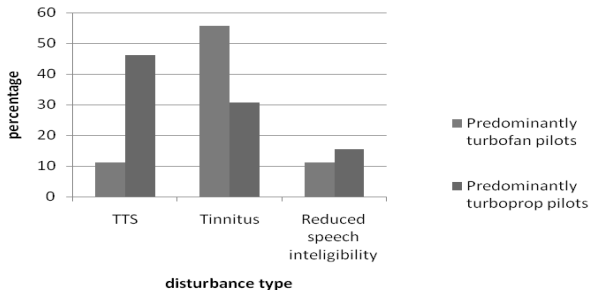

Figure 4. Percentage of the audible noise disturbances in relation to the prevalent type of aircraft flown

Table 1. Average subjective rating of influence of different types of noise in the cockpit on flight safety (1- no influence, 5 - maximum effect)

	Turbofan	Turboprop
APU and air condition noise on apron	2,7	3,4
Take-off noise (dominantly due to high engine power)	3	3,5
Cabin noise while cruising (result of joint action of airborne and structure borne noise, mostly due to powerplant and aerodynamic airflow)	3	3
Noise on landing approach (dominant aerodynamic airflow over the landing gear, flaps, landing gear cavity storage, air brakes)	2,3	2,3
Touchdown noise (wheel friction, impact on runway)	2,2	2
Roll-off noise (wheel rolling noise – noise and vibrations, noise from thrust reversers)	3,1	2,8
Sound signalization from different systems (safety systems, failure warning system or imminent danger warning system)	3,4	3,9
	2,8	3

Table 2. Subjective assessment of compromised flight safety due to the high level of noise in the cockpit

		Turbofan	Turboprop
Percentage of pilots whose flight safety was compromised once as a result of noise disturbance		27,8	38,5
Percentage of pilots whose flight safety was compromised more than once as a result of noise disturbance		5,6	7,7
Distribution of severity of events caused by cockpit noise	serious incident	42,9 %	37,5 %
	major incident	14,2 %	12,5 %
	significant incident	42,9 %	50 %

5. DISCUSSION AND CONCLUSION

In this paper, on a random sample of more than 30 pilots, no firm evidence of respondents' subjective ratings to the auditory effect of noise; TTS and tinnitus as well as symptoms of vibroacoustic disease in relation to exposure time defined by the working age of male respondents from different airlines has been found. Subjective feeling to audible noise disturbances according to working age and to the type of aircraft which the respondents were flying on are presented at Figures 1 and 4. Figure 1. shows

that TTS is equally represented in all tree age groups of pilots, but tinnitus and speech intelligibility problem is associated with pilots with longer working experience.
Tinnitus and speech intelligibility problem grows in time with working years. Percentage of the symptoms occurrence according to the VAD stages in relation to the pilots working age is presented at Figure 2. Severe stage symptoms begin to appear with more working years, mild stage symptoms of VAD are most noticeable in pilots with lowest work experience. The possible existence of known and evident symptoms of VAD is presented at Figure 3. Symptoms of VAD are most common in pilots flying turboprop type of aircraft. Percentage of the audible noise disturbances in relation to the prevalent type of aircraft on which the pilot flew is presented at Figure 4. TTS and speech intelligibility problem are more expressed in pilots flying on turboprop aircraft, but appearance of tinnitus is expressed more in pilots flying turbofan engines. Average subjective rating of influence of different types of noise in the cockpit on flight safety (1- no influence, 5 - maximum effect) according to the reverent type of aircraft on which the pilot flew is presented in Table 1. Average rating of noise in the cockpit on flight safety is more expressed in turboprop aircraft than in turbofan aircraft by subjective assessment of pilots.
Looking at the overall average rating of the impact of noise in the cockpit on flight safety (Table 1), according to the subjective opinion of a pilot, its impact is greater for turboprop aircraft (3) compared to turbofan aircraft (2,8). Subjective assessment of compromised flight safety due to the high level of noise in the cockpit is presented in Table 2, which shows that percentage of pilots that endured compromised flight safety is more common in turboprop aircraft than in turbofan aircraft, which indicates that subjective assessment of the pilot that “turboprop aircraft makes more noise” is quite correct and that something needs to be done on this issue.
To come to firm conclusion regarding relationships between percentage occurrence of some researched factors of disturbance and the type of aircraft the pilots are flying on, it would be necessary to significantly increase the number of randomly selected pilots and undergo thorough audio logical survey. Further research on this topic is in progress in domestic as well as in global aviation community in order to gain better understanding of noise impact on pilot staff.

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PHYSICAL WORKLOADS AND CARPAL TUNNEL SYNDROME AMONG DENTISTS IN "ISMAILIA CITY"

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Abstract:

Paper objective is to assess the association between physical workloads and carpal tunnel syndrome among dentists in Ismailia city. A total of 113 dentists were interviewed for assessment of physical workloads and symptoms of carpal tunnel syndrome (CTS) using interview questionnaire and physical examination. Diagnosis of CTS was confirmed by measurement of nerve conduction velocity for cases suspected to have CTS by history and physical examination. The prevalence of CTS among dentists was 23% it was higher in females (14.2%) compared to males (8.8%). The mean duration of occupation in the dentists positive for CTS was 13.69±10.8 years, the mean hours worked per week was 32.35±6.4 hours and the mean days worked per week were 5.3± 0.62 days. The relation between CTS and duration of work in years, number of hours worked per week, and number of days worked per week was statistically significant. Predictor of carpal tunnel syndrome among dentists were; frequent bending and twisting of the wrist, duration of work in years, hours worked per week, and age in years. Twenty three percent of dentists had CTS. Avoidance of excessive bending and twisting of the wrist and frequent repetitive motions of the hands during dental procedures reduces the stress on the median nerve.

Keywords: *dentists, physical workload, carpal tunnel syndrome, nerve conduction*

1. INTRODUCTION

Musculoskeletal disorders represent an important occupational health issue in dentistry. The abnormal postures adopted by dentists cause discomfort and disorders of the musculoskeletal system and the peripheral nervous system [(1)]. Even with the best ergonomic equipment, operators can find themselves in sustained awkward postures [(2)]. Alexopoulos et al. found that 62% of dentists reported at least one musculoskeletal complaint, 30% of them suffered from chronic complaints, 16% had spells of absence and, 32% sought medical care due to their musculoskeletal complaints [(3)]. Hand and wrist disorders were receiving the most attention, although their symptoms were reported less often by dental workers than symptoms of neck and/or back disorders. It may be that the motivation for interest in this area has been spurred on by the observed significant increase in workers' compensation claims for disabilities in this area [(4)]. Repetitive strain injuries (RSI) are defined as cumulative trauma disorders (CTD) resulting from prolonged repetitive, forceful or awkward movements. These movements result in damage to muscles, tendons and nerves. RSIs are referred to as repetitive stress

injuries, occupational overuse injuries and work-related musculoskeletal disorders. RSIs also can refer to well-defined disorders such as carpal tunnel syndrome (CTS) [5]. CTS is one of a number of muscle-, tendon- and nerve-related disorders that affects people performing intensive work with their hands. Through these people there has been a tremendous increase during the last 20 years in the numbers of reported cases of CTS.
Both dentists and dental hygienists have been reported to have a high prevalence of upper-extremity musculoskeletal disorders, including CTS [6]. Lalumandier et al. found that the prevalence of CTS among dentist was 56% [7]. A study noted a growing incidence of CTS among dentists. All of them support the idea of work as a causal factor in the development of CTS among dental professionals [8]. The work-related risk factors associated with CTS and other hand disorders include repetitive hand motions, forceful pinching or gripping, sustained awkward wrist postures, and vibration. Most of these risk factors are present in dental practice; holding dental instruments may require a high level of pinch force, and the wrists may be held in awkward positions for prolonged periods [9].

2. SUBJECTS AND METHODS

The study was a cross-sectional analytic study. A convenient sample was taken including all dentists worked in faculty of dentistry Suez Canal University, Suez Canal University Hospital, Ismailia General Hospital and Health Insurance Hospital in Ismailia city. One hundred and thirteen dentists participated in the study. Dentists included were both males and females with at least 1 year of work experience in the current position[3].Subjects were assessed by interview questionnaire including information on the respondent's sociodemographic data, occupational history, physical workloads concerning repetitive movements, strenuous arm positions like working with hands in excessive tightening, and use of vibrating tools. A four-point scale was used with ratings 'never', 'sometimes', 'often', and 'always' during a regular workday. The answers 'often' and 'always' were classified as high exposure, while the answers never and sometimes were classified as low exposure [3]. Assessment for the presence of CTS was done through medical history, clinical examination and electrodiagnosis by measuring median nerve conduction velocity for confirmation of diagnosis in cases found positive for CTS by history and clinical examination. Quantitative data was expressed as mean ± SD or as adjusted mean ± SE; qualitative data was expressed as number or subjects and percentage. Chi-square test and Fisher's exact test were used to assess the statistical difference between variables. Statistical significance was taken as $p<0.05$. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS Version 11.0).

3. RESULTS

The mean age of the participants was 36.24 ± 10.06. Males were more than females (54% and 46% respectively). The mean age for those diagnosed with CTS was 35.7±11.1 while the relation between age and CTS was statistically insignificant. CTS was diagnosed in females (16 female) than in males (10 males). The relation between gender and CTS was statistically insignificant. The most common occupational group was residents being 28.3% (32) of the participating dentists. The relation between CTS

and occupational seniority was statistically insignificant. In the dentists diagnosed positive for CTS, the mean duration of occupation was 13.79±9.68 years; the mean hours worked per week were 32.35±6.4 hours and the mean days worked per week were 5.3±0.62 days as shown in Table 1. There was a statistically significant relationship between the presence of CTS and the duration of work in years, number of hours worked per week, and number of days worked per week.

Physical workloads reported by the participating dentists were: manual jobs require frequent, repetitive motions of the hands; work postures require frequent bending of the wrist and fingers; performing activities with hands raised above shoulder ; finger-pinch gripping used; job postures involve sustained muscle contraction of hands; use of vibrating tools and treating too many difficult cases one right after the other. There was a significant relationship between CTS and frequent repetitive motions of the hand and frequent bending and twisting of the wrist, while the relations between CTS and other physical workloads were statistically insignificant. Table 3 shows the relation between CTS and physical workloads.

Table 1. Relation between CTS and Different Occupational Factors in the Participating Dentists

Parameters	CTS				
	Positive		Negative		Significant Test Used
	No.	%	No.	%	
Occupation					χ^2 =0.46
Residents and Specialists	16	5.8	47	26.4	P=0.498
Consultants	10	16.6	40	51.3	
Duration of Work in Years					
<15	18	15.9	54	47.8	χ^2 =8.90
15-	3	2.7	29	25.7	P=0.012*
30-40	5	4.4	4	3.5	
Working Hours per Week					
<15	0	0.0	20	17.7	χ^2 =21.96
15-	9	8.0	50	44.2	P=<0.001*
30-48	17	15.0	17	15.0	
Working Days per Week					χ^2 =8.74
≤4	2	1.8	33	29.2	P=0.012*
5	14	12.4	34	30.1	
6	10	8.8	20	17.7	

***Chi-square test is significant at 95% confidence level.**

There were 46 (40.7%) of the dentists had complaints consistent with CTS. The main complaint mentioned by the participants was pain being reported by 34.5% (39) of the participants in one or both hands either alone or associated with paraesthesia and/or clumsiness in the hands. The mean duration of complaints was 16.04±10.2 months. Severity of pain was assessed by the visual analogue scale. About half of the participants (20, 51.3%) complaining from pain were positive for CTS. The relation between visual analogue scale and CTS was statistically significant (P=0.02). Phalen's test was more sensitive for CTS than Tinel's sign (sensitivity 86.8% and 68.4%, respectively), while Tinel's sign was more specific for CTS (59.1%) than Phalen's test (54.5%). Of the 46 complaining participants, 30 were proved to have CTS by clinical examination and special tests. NCV tests were done for the 30 participants in both hands.

Table 2. Relation between Physical Work Loads and CTS among Dentists

Physical Work Loads	Degree Of Exposure	CTS				Significant Test Used
		Positive		Negative		
		No.	%	No.	%	
Frequent, Repetitive Motions of the hands	High	19	16.8	80	70.8	Fisher's Exact Test P=0.017*
	Low	7	6.2	7	6.2	
Work Postures Require Frequent Bending of the Wrist	High	25	22.1	69	61.1	Fisher's Exact Test P=0.04*
	Low	1	0.9	18	15.9	
Frequent Bending of the Fingers	High	25	22.1	73	64.6	Fisher's Exact Test P=0.185
	Low	1	0.9	14	12.4	
Hands Raised above Shoulder Level	High	1	0.9	8	7.1	Fisher's Exact Test P=0.682
	Low	25	22.1	79	69.9	
Finger-Pinch Gripping Used	High	20	17.7	60	53.1	χ^2 =0.61 P=0.43
	Low	6	5.3	27	23.9	
Sustained Muscle Contraction of the Hands	High	15	13.3	57	50.4	χ^2 =0.53 P=0.467
	Low	11	9.7	30	26.5	
Use of Vibrating Tools	High	12	10.6	51	45.1	χ^2 =1.26 P=0.261
	Low	14	12.4	36	31.9	
Treating Too Many Difficult Cases	High	16	14.2	59	52.2	χ^2=0.35 P=0.552
	Low	10	8.8	28	24.8	

*Fisher's Exact Test is significant at 95% confidence level.

The frequency of sensory affection of the median nerve (38, 63.3% of the examined hands) was higher than motor affection (30, 50% of the examined hands). Predictors for CTS as detected by logistic regression analysis were frequent bending and twisting of the wrist; duration of work in years; hours worked per week and age in years as shown in Table 3.

Table 3. Logistic Regression Analysis of Independent Predictors of CTS among Dentists

Predictor	ß	P value	OR (95% CI)
Frequent Bending and twisting of the wrist	2.27	0.004	9.630 (2.07 -44.86)
Duration of Work in Years	0.59	0.022	1.798 (1.09 - 2.97)
Hours Worked per Week	0.22	<0.001	1.242 (1.13 - 1.37)
Age in Years	-0.56	0.022	0.574 (0.36 - 0.92)
Constant	4.60	0.356	99.599
Model χ^2 = 51.02		<0.001	

4. DISCUSSION

In the present study the frequency of CTS diagnosis was higher among females (30.8% of females) than males (16.7% of males). Several reasons can explain the differences in the relationship between CTS and gender among different studies. Many women often perform the majority of hand-intensive work at home in addition to their paid jobs. Boz and his colleagues found that wrist index (antero-posterior measure/lateral measure) was found to be a more significant risk factor for CTS in females (P<0.001) than in males (P=0.034). Logistic regression analysis revealed the wrist index to be an independent risk factor in females, but not in males[10]. On contrast, Hamann et al. found that dentists diagnosed with CTS tended to be older than those who were not diagnosed but the difference between the two means was statistically insignificant[6]. The most common occupational group among the participant dentists was residents (28.3%). There was no statistical relationship between CTS and occupational category[11]. The mean years worked by the participants diagnosed for CTS was 13.96±10.8. There was a statistically significant relationship between CTS and duration of work in years (P=0.012). Legaat and Smith studied musculoskeletal disorders reported by dentists in Queensland, Australia. In their study, dentists had work duration of 14.3±9.1 years. They stated that dentists who had practiced more than 10 years were 1.9 times more likely to manifest symptoms associated with CTS than those with fewer years in the profession [12]. The mean days worked per day by the participants were 4.7±1.2 days and the mean hours worked per week were 24.12 ± 9.19. There was a highly significant relationship between CTS and the number of working hours per week (P=<0.001), and number of working days per week (P=0.012) due to prolonged duration of work and increasing workload. In Legaat and Smith's study, dentists' mean working hours per week were 31.6±9.4 hours. Dentists who worked longer hours during the week were more likely to have hand and finger symptoms and to have median mononeuropathy as well[12]. The main complaint reported by the participants in the current study was pain sometimes associated with paraesthesia. It was found that 24(88.8%) of those having pain were diagnosed for median mononeuropathy as confirmed by electrodiagnostic testing. In the current results symptoms of CTS were reported by 46 (40.7%) of the participant dentists. Pain was the main complaint it was reported by 34.5 % (39) of the participants. This agrees with what was found by Hamman et al. that 28% (258) of the participating dentists had hand or finger pain, numbness or tingling sensation [6]. In addition, Werner et al. who studied prevalence of upper extremity symptoms among dentists, found that pain in the hand, wrist and finger was reported by 23%(54) of the participating dentist [13]. In the current study, Tinel's sign was positive in 56.7% (34) of the hands of the complaining participants. Sensitivity of Tinel's sign to CTS was 65.8% and specificity was 59.1%. This agrees with Gupta and Benstead who stated that Tinel's sign is associated with sensitivities of 23% to 67%, and specificities of 55% to 100%[14]. Phalen's test was positive 71.7% (43) of the hands of the complaining participants. The sensitivity of Phalen's test for CTS was 86.8% and specificity was 54.5%. This agrees with what Bruske and his colleagues found that sensitivity of Phalen's test ranged between 10% and 91% and specificity between 33% and 100% [15]. There was a statistically significant relationship between CTS and frequent repetitive motions of the hands (P=0.02). Bramson et al. evaluated risk factors and hazards in dental office ergonomics across the United States. They stated that repetition of hand motion greater than 30 movements per minute for long periods could lead to painful disorders in the hands and wrists. These highly repetitive tasks are of concern if they are performed

more than 20 hours per week [16]. In this study, 61.9% (70) of the participants had work postures that required frequent bending of the wrist joint >75% of the work time. There was a statistically relationship between CTS and frequent bending of the wrist joint. Dong et al. stated that work-related risk factors included repetitive forceful pinching or gripping, sustained non-neutral wrist positions and use of vibrating tools. In addition, gaining and maintaining access to some areas of the oral cavity may require the wrists to be held in awkward positions for prolonged periods[9]. Other studies about the prevalence of CTS among dentists one of the factors associated with the high prevalence of CTS among dental practitioners is the repeated high pinch force applied during work [9, 17, 18]. CTS was found in (23%) of the participating dentists, associated with increased duration of work in years and number of hours and days worked per week as well as repetitive hand motions and excessive bending and twisting of the wrist. Avoidance of excessive bending and twisting of the wrist and frequent repetitive motions of the hands during procedures reduces the stress on the median nerve.

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PHYSICAL WORKLOAD ASSESSMENT OF COFFEE FARM WORKERS

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Abstract

The main objective of this research was the assessment of the physical workload of coffee farm workers from southern Minas Gerais, Brazil. Twelve workers were filmed having their heart rates monitored during one hour of execution of twelve different tasks, both on flat and sloping terrain. An assessment of the workers adopted body postures was carried through the "Captiv" software. An identification of pain body areas was carried by means of the Corlett diagram, as well as a subjective evaluation of perceived effort using the RPE Borg scale. The results showed that the proposed method is an efficient tool to characterize the physical workload in an agricultural context.

Keywords: *physical workload, heart rate, postural analysis, coffee production*

1. INTRODUCTION

Agribusiness is responsible for 33% of Brazil's gross domestic product, 42% of total exports and 37% of Brazilians jobs, employing about 17.7 million workers, occupying a prominent position in the Brazilian economy [1]. Coffee production is very important in the context of the Brazilian economy since Brazil is responsible for about a third of the world production, which makes the country the largest producer - a position maintained in the last 150 years. Today, Brazil has a planted area of 2.3 million hectares, with about 5.7 billion coffee trees. The state of Minas Gerais is the largest producer in the country with 45.5% of the Brazilian production [2].

There are many researches on coffee production regarding technical, agronomic or socio-economic issues; few researches, however, try to identify the characteristics of the human workload of the coffee farming, under an ergonomic perspective. In that sense, a participatory ergonomics approach was used during two Nicaraguan shade-grown coffee harvesting seasons to reduce the physical load on harvesters with the use of a newly designed bag instead of a basket strapped around the waist. Among basket users, 84.2% reported pain in at least one body area compared to 78.9% of bag users. Nonetheless, 74% of participants liked the bag much more than the basket [3].

Being mostly a non-repetitive, non-monotonous type of work, agricultural work needs a group of methods, both objective and subjective, to characterize its workload. In this perspective, a study was done aiming the characterization of the physical workload of the organic horticulture, by determining the frequency of exposure of operators to some activity categories. The approach included an evaluation of physical effort demanded to perform the tasks in the work systems from a systematic sampling of work situations from a synchronized monitoring of the heart rate; a characterization of posture repertoire adopted by workers by adapting the OWAS method; an identification of pain body areas using the Corlett diagram; and a subjective evaluation of perceived effort using the RPE Borg scale. The results of the individual assessments were cross correlated and explained from an observation of the work activity. Postural demands were more significant than cardiovascular demands for the studied tasks, and correlated positively with the expressions of bodily discomfort [4].

Heart rate is traditionally used as an indicator of physiological effort, being increasingly used instead of oxygen consumption to estimate the workload of a task [5]. Cardiovascular parameters commonly used include the average heart rate during work − the working heart rate (HR_W), the resting heart rate (HR_R), the maximum heart rate (HR_{max}), the limit heart rate (HR_L) and the relative heart rate (HRR) [6]. HRR at work is an important indicator of physiological strain and should not exceed 40% for an eight hour period to avoid fatigue [7]. HR_W is also used as an strain indicator and determines the following categories of work intensity: light (HR_W<90); moderate (90≤HR_W<110); heavy (110≤HR_W<130), very heavy (130≤HR_W<150) and extremely heavy (HR_W> 150) [8].

The effects of workload on the individual can also be estimated through the use of psychophysical methods (body discomfort and body pain surveys) that can be applied to assess the physical effects of the workload [9]. Also, to assess the subjective perceived exertion for each task it can be applied the RPE (rate of perceived exertion) Borg scale [10].

The main objective of this work was the assessment of the physical workload in an agriculture context, applying the proposed method in a case study of the work on coffee farming system. This kind of study can help to direct research efforts towards the technological development of coffee farming, both to improve human work productivity and to reduce ergonomic hazards.

2. METHODS

The proposed study is experimental under field conditions with quantitative and qualitative elements. The descriptors of the physical workload are the group of dependent variables, including those of physiological (heart rate, cardiovascular load), biomechanical (postural combinations) and psychophysical nature (indication of physical discomfort and perceived exertion). The independent variables are composed by tasks, subtasks and the topography of the farms.

Twelve workers from twelve small family coffee farms from Santo Antonio do Amparo, southern Minas Gerais, agreed to participate in this study. Each subject was voluntary and received adequate information about the research. They had the right to withdraw from participation at any time, without penalty of any kind and without providing reasons. Each of them was filmed performing one hour work of the subtasks, both in flat terrain and in areas with more than 10% slope (with the exception of the subtasks from

the post-harvest group, that were performed only in flat terrain). The heart rate (HR) was measured continuously for each subject, synchronized with the video recording. A Polar RS800CX G3 heart rate monitor was used with a sampling rate of 2 seconds.
Table 1 shows personal and biometric data of the workers.

Table 1: Personal and biometric data of the workers.

Worker	Gender	Age (years)	Seniority (years)	Weight (kg)	Height (cm)	HR_R (bpm)	HR_{max} (bpm)
1	M	59	22	64	165	66	161
2	M	30	8	93	179	52	190
3	M	60	11	70	171	63	160
4	M	30	10	60	163	59	190
5	M	40	20	94	187	64	180
6	M	34	9	63	165	56	186
7	M	31	20	61	172	66	189
8	F	25	6	66	160	53	195
9	M	35	20	100	190	65	185
10	M	39	19	84	182	67	181
11	M	29	20	74	180	53	192
12	M	68	39	54	169	71	153

The tasks from the coffee farming systems considered in this study are crop handling and harvest. They had the following subtasks and respective operations:
a) **Crop Handling** − manual fertilization (empty bag displacement, bag stuffing, full bag displacement and manual fertilization); foliar fertilization (empty costal pulverizer displacement, costal pulverizer refuelling, full costal pulverizer displacement and application); thinning (thinning); herbicide application (empty costal pulverizer displacement, costal pulverizer refuelling, full costal pulverizer displacement and application).
b) **Harvest** – harvest (canvas placement, manual harvest, canvas displacement, sieving, manual cleaning and bagging).
To assess the perceived exertion for each subtask, each subject had to indicate their perception on a Borg scale, ranging from 1 (very light) to 7 (extremely intense). It was also used a body part discomfort scale to assess the levels of body discomfort of the workers at the end of the workday. The heart rate indicators adopted in this work were calculated as follows [7], [8]:

$$HR_{max} = 220 - age \quad (1)$$

$$HR_L = 0{,}40(HR_{max} - HR_R) - HR_R \quad (2)$$

$$HRR = \frac{(HR_W - HR_R)}{(HR_{max} - HR_R)} \times 100 \quad (3)$$

The postural protocol was adapted from OWAS [9] to include the characteristics postures of coffee farm labor (Figure 1).
The experiment was conducted in a randomized block design, where each worker was considered a block in a 5x2 factorial design. The factors were slope and the subtasks. It

was performed an analysis of variance and the Tukey test was applied to compare means.

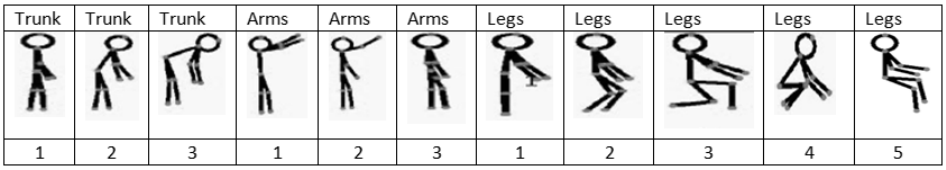

Figure 1: Postural protocol adopted.

3. RESULTS

The mean heart rate results and the standard deviation for the twelve workers performing all subtasks in both topographic conditions are summarized on Table 2.

Table 2: Heart rate results for workers performing all subtasks.

Worker	HR_W ± SD	HRR ± SD
1	88,9 ± 5,1	24,11 ± 5,4
2	90,0 ± 5,8	27,54 ± 4,2
3	95,5 ± 3,9	31,05 ± 4,1
4	105,8 ± 5,1	38,99 ± 3,7
5	79,9 ± 2,0	14,63 ± 2,2
6	98,9 ± 3,3	33,99 ± 2,4
7	96,8 ± 2,9	32,42 ± 3,1
8	96,2 ± 6,1	32,03 ± 4,4
9	81,6 ± 4,5	16,42 ± 4,8
10	88,4 ± 5,7	26,38 ± 4,1
11	101,2 ± 4,2	37,05 ± 4,4
12	85,9 ± 4,4	24,57 ± 3,2

Table 2 shows that 58,3% of the workers exhibited HR_W between 90 and 110 bpm, configuring moderate work intensity, while 41,7% had HR_W less than 90 bpm, configuring light work intensity. All of the HRR results are under 40% and in safe limits according to the literature.

ANOVA results showed that the *slope factor* was not statistically significant with respect to heart rate results. On the other hand, the *subtask factor* was statistically significant for ($p<0,05$).

Table 3 shows mean heart rate values for all the workers performing the subtasks. Means followed by same letter do not differ at the 5% level of significance by the Tukey test. Foliar and manual fertilization exhibited significantly greater values of HR_W and HRR than the other subtasks. The results configure a moderate work intensity for foliar and manual fertilization and light work intensity for herbicide application, thinning and harvest.

The mean postural combinations adopted by the workers in percentage of the working time on flat terrain are expressed on Figure 2 for the five subtasks analyzed. Four categories were the most frequent, occurring in more than 80% of the sampling time: (131) – standing erect, arms down, extended legs; (231) - moderate trunk flexion (<45º), arms down, extended legs; (232) - moderate trunk flexion (<45º), arms down, flexed legs and (332) - severe trunk flexion (>45º), arms down, flexed legs. The postural combinations 111 (standing erect, arms up, extended legs) and 121 (standing erect, one arm up, extended legs) occurred more than 15% during foliar fertilization and thinning. Harvest was the subtask that showed the greater variety of postural combinations.

Table 3: Heart rate results for workers performing specific subtasks

Subtasks	HR_W ± SD	HRR ± SD
Foliar fertilization	99,88 ± 2,9 a	34,73 ± 2,8 a
Manual fertilization	99,46 ± 4,1 a	34,88 ± 3,4 a
Herbicide application	88,54 ± 2,3 b	24,96 ± 2,1 b
Thining	85,96 ± 2,7 b	22,40 ± 2,3 b
Harvest	88,29 ± 2,8 b	24,34 ± 2,5 b

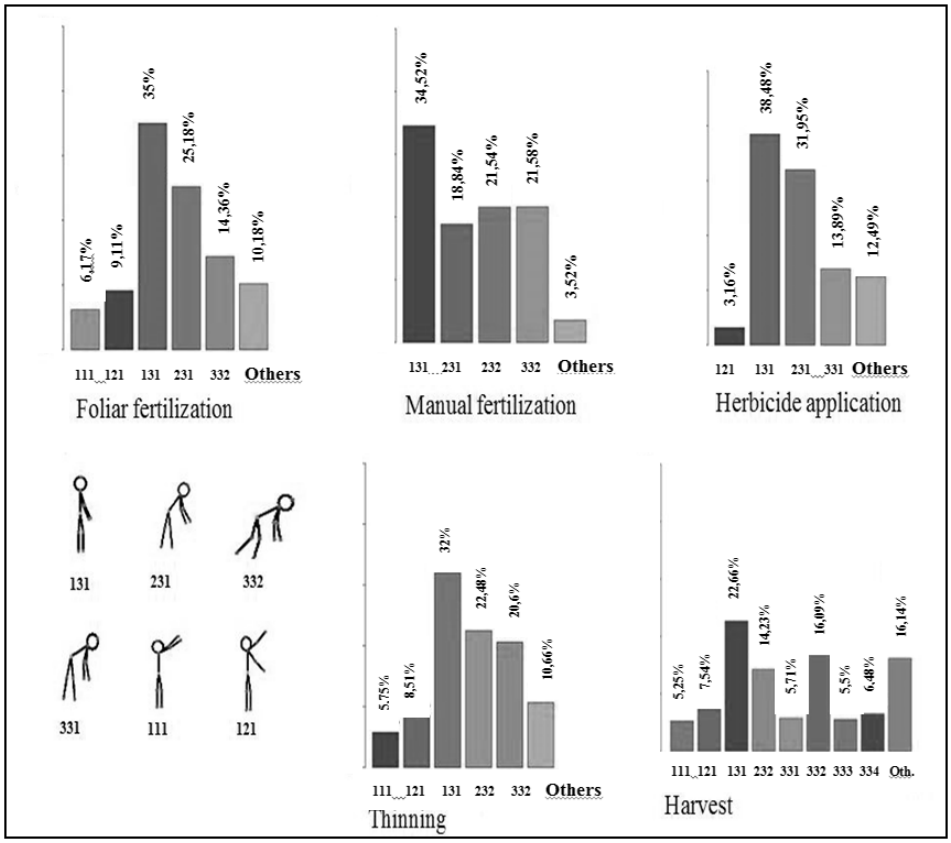

Figure 2: Postural combinations for each subtask.

The mean results of the application to all the workers of the modified Borg scale for the rate of perceived exertion (RPE) for each subtask considering the scores 5 (intense), 6 (very intense) and 7 (extremely intense) were: manual fertilization – 38%; thinning – 5%; foliar fertilization – 60%; herbicide application – 25%; and harvest – 18%.
The results of the body discomfort survey showed that the main body areas pointed by the workers with some degree of discomfort were the shoulders and the back; approximately one quarter of the workers pointed that the degree of discomfort for the shoulders and the back ranged from uncomfortable to extremely uncomfortable.

3. CONCLUSION

The cardiovascular effort was not particularly severe for the subtasks analyzed. On the other hand, the biomechanical demands expressed by some difficult postures were considerable. Manual fertilization, thinning and harvest exhibited moderate and severe trunk flexion and leg flexion during more than 25% of the work time.
Foliar and manual fertilization were pointed by the workers as the most demanding subtasks according to the BORG RPE scale. The results of the body areas discomfort analyses indicated the back and shoulders as the most uncomfortable body areas. For the foliar fertilization and herbicide application, the postural demands and the use of the manual pulverizer contributed for the complaints.
It is expected that the results of this study can benefit coffee farm workers by the characterization of their workload, helping to direct efforts towards the development of new technologies designed to minimize the workload and raise the work productivity.

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JUST ANOTHER ERGONOMIC TOOL: THE 'COMPOSITE ERGONOMIC RISK ASSESSMENT (CERA)'

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Abstract

In the Occupational Safety and Health practice as well as in the improvement of production systems some ergonomic evaluation is needed. Although a wide range of ergonomic risk assessment tools are available their usability and applicability is limited.
Based on a need analysis an ergonomic screening tool was developed implementing the requirements of the EN 1005 standard series. The three-page version is applicable for screening according to the simplest evaluation methods of the standard, while the software version is for detailed analysis. Thanks to the structure and the EN 1005 background CERA is getting more and more popular among occupational safety and health specialists and doctors in Hungary.

Keywords*: ergonomic risk assessment, ergonomic tools, Composite Ergonomic Risk Assessment*

1. INTRODUCTION

The practice of the last decade on the fields of industrial ergonomic research and result of educational experiences combined with sad statistical data of MSD in Europe despite the technical/technological developments lead us to investigate how we can help the OSH practitioners working on designing, operating and monitoring workplaces to recognize the risk of musculoskeletal diseases in the very early stage. [1] Although less than one fifth of Hungarians speaks a foreign language, European Standards, including machinery safety standards are not available in Hungarian. The aim of our research project was to bridge the gap between the Hungarian ergonomic risk assessment OSH practice and the EU requirements and international methodology level.
According to the needs analysis including interviews and legislation analysis, the new tool had to be

- Available is Hungarian (and English),
- Give a paper-and-pencil tool (the Excel version for PC is in process),
- Easy to use with useful figures and additional information (just a several hours of face-to-face or e-learning education/practice enough),

- Help to fulfill the simple procedure allowed by the standards to decide with great security whether the given situation is acceptable or not,
- Applicable within common work conditions,
- Marking the level of risk and the origin of the problems.

The target population is health and safety experts, members of ergonomic teams, participants of workplace design and members of occupational health service.
As a result we created an evaluative tool, named CERA – Composite Ergonomic Risk Assessment. Version 1.3 is currently in effect.
According to the rules descripted in series of EN 1005 "Safety of machinery. Human physical performance" standard the CERA method is suitable for assessment of risk connected with worker's posture, manual material handling, force exertion and repeated movements.
At the half time of the project we have a lot of experience about the usability of the method compared to other methodologies and information about the needs of our industrial partners working on OSH fields. We have concepts and plans also how to continue this work. There are additional plans to create versions on different platforms, not just laptop / notebook, but tablet and smart phone, too.

2. BACKGROUND AND CURRENT STATUS

The project began early in 2012 exploring the theoretical basis and studying the relevant standards. In the summer of 2012 the tool was tested (CERA 1.1 and CERA 1.2 versions). We carried out the assessment of more than 30 industrial work activities, and two office VDT work under real conditions, simultaneously using different evaluation methods. By the end of March 2013 we changed the 3 A4 landscape format assessment sheets of CERA 1.2 to 5 A4 portrait format assessment sheets of CERA 1.3 based on experiments and feedback of operating safety experts. Ongoing expansion of its other two sheets, which is suitable for the evaluation of the office work, especially VDT jobs [2].
In April 2013 the new version was also introduced to industrial safety professionals and we held a CERA exercise connected with sort lesson on risk management. The task of the participants was to assess different work activities in group and individually using video recordings.

3. A DETAILED DESCRIPTION OF CERA 1.3

The essential elements of the method are presented on evaluation sheets. To the application of this tool there are some useful notes:

1. The result of the evaluation just shows the causes of risk and not the percentile or absolute quality of the work conditions.
2. The evaluation concerns only to the **actual** work conditions of the **actual** job, not to the worker, although the results may be modified by characteristics of the worker.
3. It is advised to divide the highly different tasks of the job and evaluate it separately. The end result will be never time proportional.

3.1. The "Status and Summary" sheet

This page contains basic information and results of the evaluation.
Beyond the name/description of workplace, job and activity the evaluator can record working hours and breaks, as well as the gender and age of worker. Below the results table the percentage of standing, sitting and walking time during the shift is recorded.
At the same time it is possible to write the essential elements of work history - e.g. related activities, accidents and injuries - and other notes as the suggestions of the evaluator or the opinions of the employee. The lower right figure (human shape) allows for a simplified discomfort survey, with indication of body parts and description of complaints of the employee. The latter two possibilities - asking for opinions and complaints – are significant motivations for involvement of affected employees.

3.2. The "Posture" sheet (Figure 1)

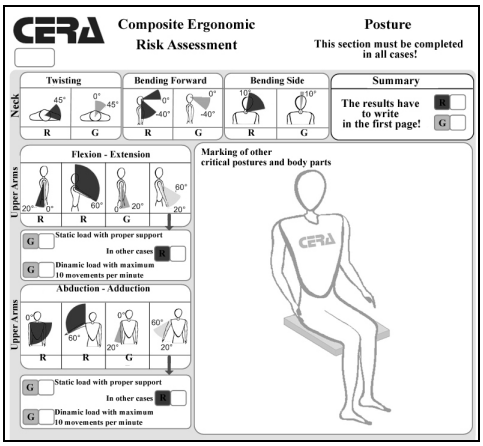

Figure 1: Detail of the Posture sheet

The assessment of posture should be performed in all cases. As a result, we get a total of 12 red and green signals. The red signals show that the position of the body parts are not correct, so the risk of MSDs high. As compared to the previous version of the tool we differ from the standard and the forearm and hand/wrist position will be evaluated too. The evaluation of head, forearm, upper arm, trunk and hand/wrist can be done by angle range of joint with the help of little figures.
There is a transitional range indicated by yellow sign at the trunk and upper arms, where it must be decided by other conditions whether the result will be green or red. The decision shall be based on the opportunity of support at static loads and on the frequency of movements at dynamic loads.
In addition to the other parts of the body not evaluated in detail the awkward postures can be indicated on the sitting human shape in the right and the reasons can be described.
The result clearly shows which position of which parts of the body have to be corrected by changing and/or developing work conditions.

3.2. The "Force Exertion" sheet (Figure 2)

The simplified procedure for the assessment of the force applied in different ways in terms of MSD risks will only be possible if four conditions meet. These conditions derived from the standards are the followings:

1. It can be stated that the duration of work does not exceed 8 hours.
2. It can be stated that the duration of exertion does not exceed three seconds.
3. It can be stated that there are no more than two exertions per minute.
4. A pre-condition for examining exertion is that the part of the body concerned should not be considerably displaced and any motion should be slow and without jerking.

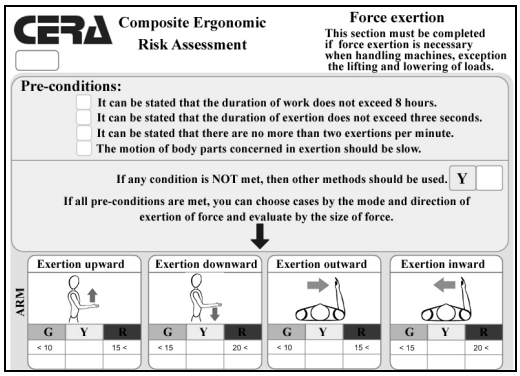

Figure 2: Detail of the Force sheet

In the simplified evaluation, any of the determined 13 base cases must be considered, with the body parts which involved in force exertion and the threshold of force is given in N for Green and Red zone. If it is true, that in every case the result is Green the force exertion is acceptable, otherwise further investigation needed.

3.3. The "Manual Material Handling" sheet

The simplified procedure for the assessment of the manual material handling jobs in terms of MSD risks contrary to the force exertion will only be possible if twelve conditions derived from the standards meet But before that there are three other excluding criteria defined by the research team, to exclude the trivial dangerous situations, labeled as Red case. These are:

1. The load lifted by the worker exceeded 25 kg, or 50 kg by two workers.
2. One adult is moved by a person without lifting aids. (Defined for use in health care services.)
3. The lifting or lowering happens regularly over the height of shoulders.

Conditions derived from standard:

1. Horizontal weight displacement may not exceed two meters.
2. Manual material handling is performed while standing, the employee is not hindered by external obstacles in executing the correct lifting method and no level differences need to be overcome during movement.
3. Lifting is performed by only one person, using only muscular power.

4. There are no rapid movements, jerks, or jams during lifting.
5. The object moved can be grasped properly, meaning that it has a grasp or grip to be grabbed properly by both hands.
6. The object moved can be held against the body, meaning that it is not too cold or not too hot and not polluted.
7. Legs do not slip, so the floor is not oily, icy or wet, for instance.
8. No other operation is required to be performed in the course of the operation in addition to lifting the object concerned.
9. There are no extreme environmental factors such as too hot, too cold, vibration, darkness.
10. The manner of lifting is correct, meaning that the worker performs lifting with two hands, by grasping the object symmetrically, and this is made possible by the shape of the weight.
11. The manner of lifting is correct, meaning that the trunk is upright, it does not lean sideways, and there is no need of tilting.
12. The manner of lifting is correct, meaning that the worker holds the weight close to the body.

It is very hard to meet all this conditions, but clearly shows how to achieve the nearly ideal lifting state.
In the simplified evaluation, it must be considered whether at least one of the determined 5 base cases, where the weight, the range of the lifting/lowering, the frequency of handling is within the limits. If it is true, the manual handling is acceptable, otherwise further investigation is needed.

3.5. The "Repeated Movements" sheet

The simplified procedure for the assessment of the repeated movement in terms of MSD risks will only be possible if four conditions meet. These conditions derived from the standards are the followings:

1. The work can be characterized by operational cycles if a given series of operations is repeated.
2. If the work is primarily not intellectual, or it does entail the visible movement of the upper limb, this assessment is required.
3. Activities characterized by operational cycles make up 4-8 hours in the course of the shift.
4. There are at least three minimum 10-minute breaks.
5.

In the simplified evaluation, it must be considered whether at least one of the determined 5 cases, where the number of actions, the cycle time, the awkward posture, the environmental conditions and the exerted force are limited in different forms. If all of conditions within the case are true independently for both hands, the repeated movements are acceptable, otherwise further investigation is needed.

6. THE VALIDATION OF TOOL

As we mentioned, parallel with the CERA experiment the analyzed work activities were also evaluated using other tools, as REBA, JSI and MAC depending on the nature of the activity. Since in most of the cases the REBA was the control tool Table 1 shows the result of the comparisons for posture. Whereas, if during the testing we used the CERA

XLS 1.2 version there are no data for some body parts which are listed in CERA 1.3. The reasons of large differences in equivalence are the consequences of difference in the range of joint angles at the two methods and lack of human and technical resources for more detailed research.

Table 1: Comparison of CERA and REBA results at posture assessment

Assessed body part and direction	Number of nearly equivalent cases	Equivalence in %
Head/neck bending forward and back	15	58
Head/neck twisting	15	58
Head/neck bending sideward	26	100
Trunk bending forward and back	3	17
Trunk twisting	15	58
Trunk bending side	10	38
Upper arm forward	11	42
Upper arm sideward	10	38

We could understand the limits and barriers of each used method and recognize which factors are available for validation, and which ones for additional value to evaluation increasing the reliability of the risk assessment.

7. CONCLUSION

Further development of the method is required. There will be two directions of the development:

1. to distinguish clearly the circle of industrial workplaces where the tool is applicable and where it is not, and
2. to widen the circle of workplaces where evaluation can be done outside the industry, for example office, health care, service even education.

Concerned to this 2nd goal the additional sheets for evaluation of office workplaces included VDT are in preparation. There is continuous feedback from pioneer users on both professional and educational sides. The other initiation of this goal appears in exclusive and permissive conditions of material handling and force exertion and on the other hand in the manual of the tool.

If the tests will increase in number and in variety of tasks the reliability of the modified tools will also increase and we can exactly describe the limits and the opportunities of the applicability of the tool.

By the end of 2013 we intend to publish the final paper-and-pencil and Excel version, too. The method will provide full and comprehensive Internet support and face to face training as required. We hope that the CERA will become the basic tool of ergonomic projects at small and medium enterprises in Hungary.

The CERA tool is suitable to establish and strengthen the ergonomic approach of OHS practitioners and to help the teaching of fundamentals of ergonomic workplace design.

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COMPARATIVE ERGO-ASSESSMENT OF CONTROL PANEL FOR NEW TRAMS PRODUCED IN THE REPUBLIC OF CROATIA AND BOSNIA AND HERZEGOVINA

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Abstract:

Among the most frequently used commands while operating trams in Bosnia and Herzegovina and the Republic of Croatia are: "dead man" function, brake module, accelerator, horn or bell, flashing light button, direction indicators, switching or blocking points, and commands for manipulation of the doors in passenger area. During design the most commonly used commands and their indicators for manual serving must be located according to the following criteria: within the range predominantly of normal arm reach in the central 90% of the tram driver population, inside biacromial range (shoulder width) in the central 90% of the tram driver population, within the vision field of the tram driver without turning their head, taking into account the circumstance that most of the drivers are righties and few are lefties and equally well in using the right hand, with the use of multi-purpose controller for an arm (group-related commands accelerator, brake modules and "dead man"), and in all circumstances respecting the instrumental (operational) conditioned reflexes of tram drivers. This paper presents a comparative ergo-assessment of driving cabs and control panels for the latest models of trams in Sarajevo (Satra II, produced by GRAS Sarajevo in B&H under license ČKD PRAHA which operates in Sarajevo) and Zagreb (TMK 2200, produced by Crotram manufacturers consortium in RC, which operates in Zagreb). The construction major failures were noted and this has negative effect on the drivers due to inconsistency between the sensory and motoric function and the absence of cognitive approach to study the drivers' needs. This results in increased driver perception response time and increased difficulty of the tram drivers' task.

Keywords: *the most commonly used commands, sensory and motor functions, instrumental conditioned reflex, task difficulty, cab design,*

1. INTRODUCTION

According to Fuller's TCI model from 2005 [1], ergo-assessment factors from the groups of factors "traffic environment", "transport means", and "human factor" affect the task demands. According to Sumpor [2] in his doctoral dissertation he has proven the effects of "transport means" and "traffic environment" on the factors from the "human factor". According to the open dynamic TCI model by Ray Fuller [1] the factors from the "human factor" also affect the drivers' capability as well as task

demands. In these circumstances, because the engine drivers' and tram drivers' task demand is very similar and depends predominantly on the change of speed, it can be concluded that with cab design the driver's mental workload intensity of male and female tram drivers can be programmed. Fatigue is one of the most important consequences of the workload. The feeling of fatigue from cognitive perception of drivers, according to Ashton and Fowler [3] and Figure 1, may be the reason for the occurrence of errors and may affect the perception-response time.

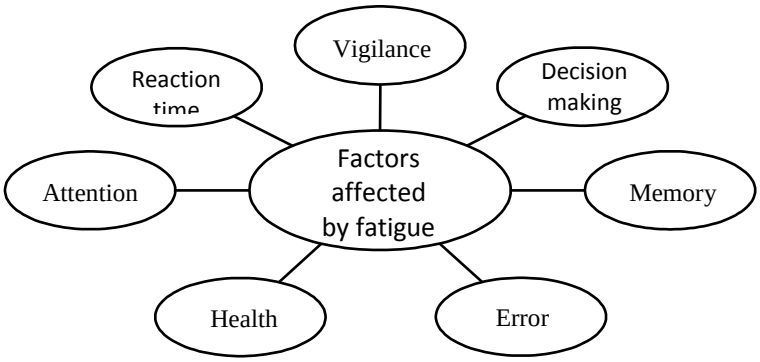

Figure 1: Consequences of fatigue
Source: Taken over from Ashton and Fowler, 2005, [3]

According to James Reason **[4] the** errors and violations have been grouped under the general heading of unsafe acts, and classified non-compliances (like errors) according to the level of performance at which they occurred: the skill-based, rule-based and knowledge-based. The five principal factors which affect the perception-response time *PRT* were analyzed by Green [5]: expectation, urgency, age, gender and cognitive load. The design of current driver cabs and control panels in trams in Sarajevo has not taken into account the ranges of the most important anthropometric measures from a random and sufficiently sample of tram drivers [6]. The same situation is in Zagreb trams. This may result from the occurrence of the subjective feeling of workload from the drivers' cognitive perception [6].

2. COMPARATIVE ANALYSIS OF MULTI-PURPOSE CONTROLLERS AND FREQUENTLY USED AND MANUALLY SERVED COMMANDS

Among the most frequently used commands while operating trams in Bosnia and Herzegovina and the Republic of Croatia are: "dead man" function, brake module, accelerator, horn or bell, flashing light button, direction indicators, switching or blocking points, and commands for manipulation of the doors in passenger area.

The multi-purpose controller for the left arm in Zagreb and also in Sarajevo is designed for group-related commands in connection with the changing of speed: accelerator, brake modules, and "dead man" function. This is a very good solution, because according to Fuller [2] the choice of speed is the primary solution of the problem of keeping the difficulty of task within the selected limits. It is impossible to conclude whether the positioning of the multi-purpose controller is better on the left or the right side of the control panel without analyzing the operation of instrumentally

conditioned reflexes and without measuring the reaction time of the tram drivers, because the majority of tram drivers in Zagreb and Sarajevo are right-handed, and a small number of them use equally well the left or the right hand during driving.

Some of the older models of trams in Zagreb, like model 2100 without trailer (produced by TŽV Gredelj) with manually served controls has an identical multi-purpose controller for group-related commands, with integrated "dead-man" function, on the left side of the tram cab and for the driver's left hand. Older models of trams like articulated models TMK 301 and 354 or model TMK T4 with trailer B4 (both produced by ČKD Praha) have foot-served commands for accelerator and brake module, both models without "dead-man" function. The old model TMK 201 with trailer TP 701 (produced by Đuro Đaković) without "dead-man" function has a combination of foot-served and hand-served commands for the braking module (more types of brakes), and hand-serving of the accelerator with left arm.

Figures 2, 3, 4 and 5 show some of the frequently used manually served commands on the tram control panel in the new tram model TMK 2200 (produced by Crotram consortium, which operates in Zagreb). The commands which are extremely within the maximum reach of the right driver's arm are: direction indicator switch, switches for setting the points, buttons for door manipulation, bell button and flashing light button. According to Table 1 male respondents in Figures 2, 3 and 4 have the value of maximal arm reach $h_{mdr} = 75\ cm$ which is closer to the centre of the central 90% for male drivers in Zagreb, and female respondent in Figure 5 have the value of maximal arm reach $h_{mdr} = 72\ cm$ which is closer to the upper limit of the central 90% for female drivers. Both respondents from Table 1 have values of maximal arm reach h_{mdr} which is closer to the centre of the total range for the central 90% of male and female tram drivers h_{mdr} = 61.9 ÷ 82.6 cm (range of maximal arm reach between the fifth percentile for female tram drivers and ninety-fifth percentile for male tram drivers).

Table 1: Comparison of standing height and maximal arm reach of male and female respondents in Figures 2, 3, 4, and 5 with the ranges of central 90% from the male and female tram drivers' population in Zagreb

Compared static anthropometric measures	Male drivers in Zagreb		Female drivers in Zagreb	
	Respondent in Figures 2, 3 and 4	52 male tram drivers from sufficient and random sample	Respondent in Figure 5	36 female tram drivers from sufficient and random sample
	Measured amount	Calculated range for central 90%	Measured amount	Calculated range for central 90%
	$h_i\ (cm)$	$\Delta h_{90\%}\ (cm)$	$h_i\ (cm)$	$\Delta h_{90\%}\ (cm)$
h - standing height	173	170.9÷191.0	171	158.5÷174.8
h_{mdr} – maximal arm reach or length of reach	75	69.7÷82.6	72	61.9÷76.8

Figure 2: Manual serving of the button for door manipulation (model TMK 2200)
Figure 3: Manual setting of points (model TMK 2200)

Figure 4: Manual serving of the bell button (model TMK 2200)
Figure 5: Manual serving of the direction indicator switch (model TMK 2200)

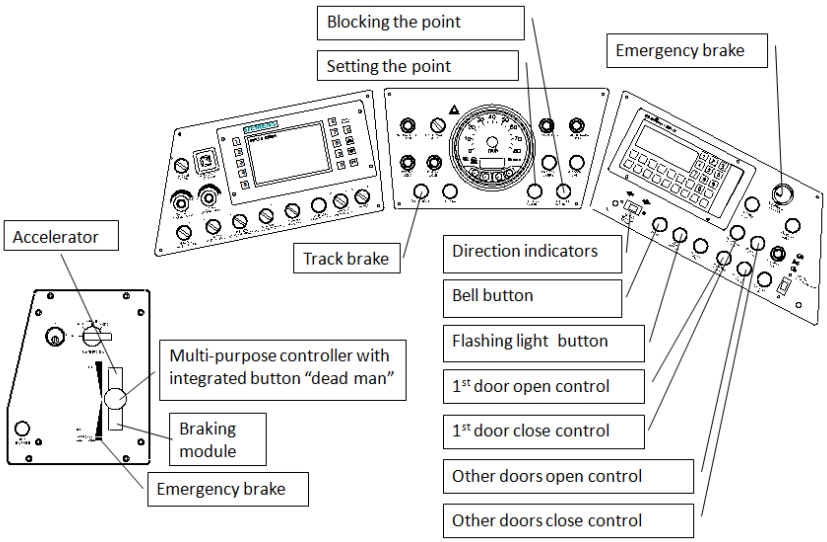

Figure 6: Control panel scheme of tram type SATRA II manufactured by GRAS, B&H

Table 2 presents a comparative ergo-assessment of the control panels for the latest models of trams in Sarajevo (Satra II) and Zagreb (TMK 2200). In both new tram cabs in Zagreb and Sarajevo there are no foot-served commands.

Table 2: Comparison of the frequently used manually served commands for the latest models of trams in Sarajevo (Satra II) and Zagreb (TMK 2200)

Frequently used manually served commands	Models of trams	
	Satra II, produced by GRAS Sarajevo in B&H under license ČKD PRAHA, which operates in Sarajevo	**TMK 2200**, produced by Crotram manufacturers consortium in Croatia, which operates in Zagreb
Horn or bell and flashing light button (near the bell button)	Predominantly inside the range of normal arm reach, better solution than in Zagreb and closer to the centre, predominantly inside the biacromial range, bell button is first button in a row, flashing light button is the second button in a row, at the bottom of the right module an arm rest for the right arm	It is too much to the right, outside the biacromial range, outside the range of normal arm reach, buttons are not visually and physically separated (especially the bell button), bell button is the second button in a row, flashing light button is the third button in a row
Direction indicators	Predominantly inside the range of normal arm reach, better solution than in Zagreb and closer to the centre, predominantly inside the biacromial range, a visually and physically separated switch, at the bottom of the right module an arm rest for the right arm	It is too much to the right, outside the biacromial range, outside the range of normal arm reach, the second switch in a row
Switching or blocking points	Outside the range of normal arm reach, better solution than in Zagreb, in the middle of tram control panel, inside the biacromial range, in the field of vision without turning the driver's head	It is too much to the right, outside the range of normal arm reach, outside the biacromial range, the drivers must turn their head, the first switch in a row
Manipulation of the doors in passenger area	Predominantly inside the range of normal arm reach, outside the biacromial range, better solution than in Zagreb, at the bottom of the right module an arm rest for the right arm	Outside the range of normal arm reach, outside the biacromial range and outside the driver's field of vision, the drivers must turn their heads, the smallest female drivers use a pencil during serving
Accelerator	Multi-purpose controller for the left arm designed for group-related commands in connection with the changing of speed, it is too much to the left and too much to the back, outside the field of vision of the tram drivers without turning their heads, outside the biacromial range	
Brake module		
“Dead-man" function		

According to Figure 7 the right module of control panel in the model Satra II with some of the most frequently used and manually served commands (bell, flashing light button, direction indicators, manipulation of the doors in passenger area) has at the bottom of the module an arm rest i.e. handle for the right arm.

Figure **7**: Control panel in the tram type SATRA II, manufactured by GRAS, B&H

3. DISCUSSION AND CONCLUSION

Control tram panels in Sarajevo and Zagreb are very similar, with a very similar arrangement of commands for manual serving, because they have been probably copied with little changes from a same model. The tram control panel in the new tram in Zagreb is nicer in relation to Sarajevo, but the tram control panel in the new tram in Sarajevo has slightly better ergonomic solutions for the part of the frequently used and manually served commands. The cognitive approach to study the drivers' needs and research the feedback from cognitive drivers' perception are necessary for the application of better ergonomic solutions during designing. The instrumental (operational) conditioned reflex of tram drivers due to past experience in different cabs need to be studied by comparing the deployment of the commonly used commands for all models of trams operating in Zagreb and Sarajevo, at the same time by measuring the response-reaction time of the tram drivers, depending on foot-serving or hand-serving with left or right extremity.

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ERGONOMIC DESIGN OF HANDLE USING RAPID PROTOTYPING TECHNOLOGY

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Abstract

This paper describes a practical and simple approach to designing ergonomic handles using software for 3D design and equipment for rapid prototyping. The new technologies reduce costs and allow manufacturing of ergonomic parts in short period of time. The feasibility of this approach was verified with the development of custom made ergonomic handle for wheelchair. The handle was designed using a hand-grip impression in the clay model. After acquiring a hand-grip impression the model was digitized with Steinbichler Comet5 3D scanner. CAD model of the ergonomic handle was designed upon on the cross - sections obtained from the .stl scanner file. The prototype for assessment was built on the ZCorp 3D printer.

Keywords*: 3D design, rapid prototyping, 3D scanning*

1. INTRODUCTION

Since the world market is in constant development, the companies have realized the importance of ergonomics because ergonomically designed products have a competitive advantage in the marketplace.
A product may be simple or complex; however, its development process involves a series of events of identifying the user's needs, defining design concepts, making a prototype, testing usability, and releasing a product to the market [1].
When developing new products it is important to ensure short development, i.e. to ensure that the new product goes to the market as soon as possible.
In order to shorten the development time it is essential in the early stages create a prototype (working model of the product) to be used for testing. After determining the initial shortcomings, the prototype is being redesigned. This process is repeated until satisfactory results are achieved in all areas: functionality, aesthetics, ergonomics, safety, etc [2].
Building a working prototype depends on available technologies, e.g., handiwork or rapid prototyping [3, 4]. Many ergonomic guidelines are available in the literature, but these are often too general for specific applications, therefore ergonomists need to extract concrete information from the guidelines for a specific product [5].

Rapid prototyping technology has the potential to capture ergonomics data (*3D scanning*) and to make a transfer of information (*CAD software*) which are needed for producing an ergonomically designed product. Further in this paper the procedure of capturing analog information and producing a mathematically defined model in CAD environment will be demonstrated. The final result is working prototype made using 3D printing technology. Figure 1 shows the general process of handle development.

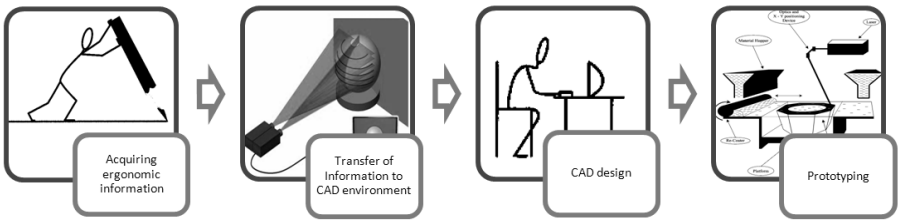

Figure 1: General process of handle development.

2. CAD MODEL DESIGN

It is suggested that ergonomics knowledge be considered at the earliest stages of the development process. A development team typically takes the user's needs and ergonomics data and then brainstorms imagined potential designs [1].

2.1. Acquiring ergonomic information

As a starting point for the development of new products designer is often a person which makes a concept, i.e. a draft that product engineers later form into the actual product. In this case the input information is a hand – grip impression in the clay model, which defines all the essential characteristics of the product, such as the basic dimensions and cross – sections. The clay impression was acquired from the client so that handle would be a perfect fit. Figure 2 shows the clay model.

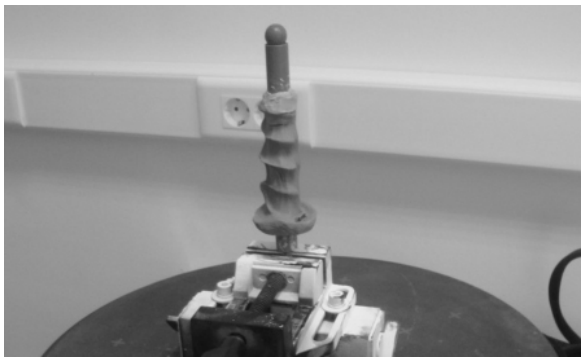

Figure 2: Clay model of a hand – grip impression prepared for scanning

2.2. Transfer of ergonomics information to CAD environment

After acquiring the clay impression, information needs to be digitized so that we could get a 3D model on the computer. Part digitization is accomplished by variety of contact and non-contact digitizers [6]. In this particular case the transfer of information was done with non-contact digitizer, Steinbichler COMET5 3D scanner. The point cloud obtained from a several scans was afterwords processed and converted into the .stl file. The cross – sections of a future CAD model were extracted from the .stl file using Steinbichler COMETplus software package. Figure 3 shows the .stl file with extracted cross – sections.

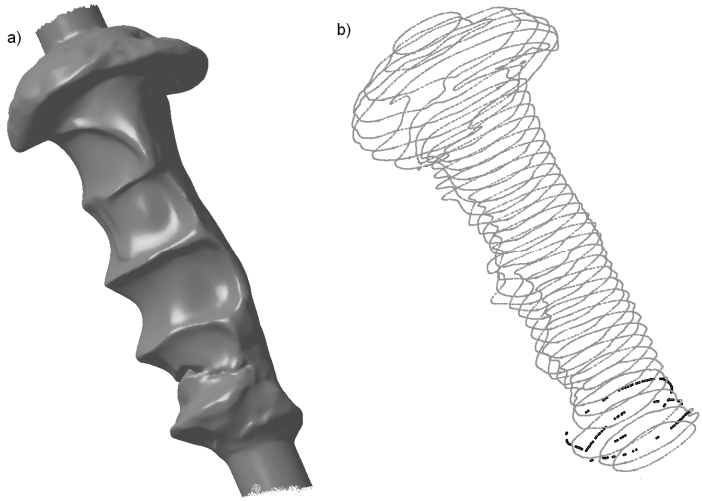

Figure 3: .stl file a); extracted cross – sections b).

2.3. CAD modeling

After extraction from the .stl file, cross – sections were imported in CatiaV5 software package. The CAD model of a handle was designed within the module *Wireframe and Surface Design*. Due to the demanding geometry a framework plan of design process has been created and divided into several stages (Figure 4).

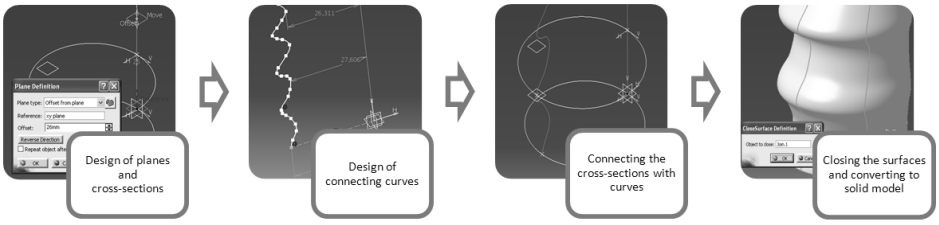

Figure 4: Sequence of the design process.

For quality design it is very important to make cross – sections, which can later be easily modified [7]. The geometry of the handle was designed using *Multi-section surface* function and finally connected with *Join* function into a single surface and converted to a solid object (*Close Surface*). After applying radiuses on the sharp edges Cad model was exported in the .stl format file. Figure 4 shows a CAD model ready for 3D printing or rapid tooling.

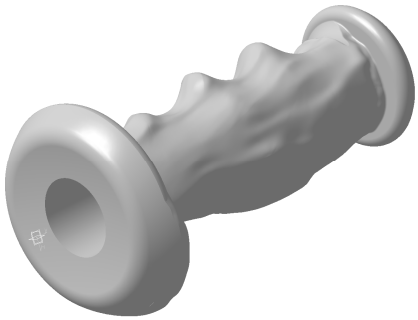

Figure 5: CAD model of a handle.

3. PROTOTYPE MANUFACTURING

3.1 Process of 3D printing

3D printing technology has been developed in the early 1990s - by the Massachusetts Institute of Technology in the USA. Thermoplastic, metal, ceramic or composite powders are used as building materials. The building material is applied to the platform by means of roller, and then the printer head applies binding glue, what leads to selective connecting particles of powder. The building platform is then lowered to the height of the layer and the whole process is repeated. Upon completion of the print job the model should be strengthen by dipping or coating with certain adhesives or resins [8][9].

3.2. Prototype production on the 3D printer

No matter which technology we use to create 3D models, the procedure that leads to the finished prototype is always the same and consists of the following steps:

1. Design of products in CAD / CAM software package,
2. Converting CAD model to .stl format,
3. Preparation of 3D printer for operation,
4. Printing model in layers,
5. Additional postprocessing of the created models,
6. Application.

After completion of the design process .stl file is imported in the ZPrint software package. This software is used to define the settings and options of printing process.

The model is positioned in a working volume of 3D printer in such a way to provide the highest quality of demanding surfaces and to minimize the print time. To avoid the stepped structure that could be pronounced in the curved surfaces for thickness of the print the smallest possible value was selected (0.089 mm). ZPrint also gives a report on the amount of materials consumed in the printing process of the model (62,09 cm3). After printing the model is left in the 3D printer at least 45 minutes to preserve the geometric stability. After cleaning the excess powder and fixing with Z - Bond adhesive physical model is ready for use.

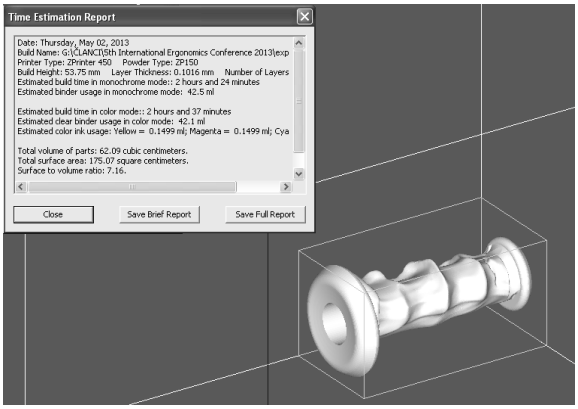

Figure 6: Model placed in the working volume of the 3D printer.

In Table 1 are listed the actions that were conducted in the process of prototyping with associated times from which is to see that finished prototype of a new product comes in a very short period of 2 – 3 days, which compared with the conventional methods is much faster, more accurate and ultimately better. Prototype production using common methods with constant improving and redesigning of template usually takes a lot longer than few days.
With the appearance and implementation of systems for rapid prototyping during the mid - 1990s duration of development projects have significantly decreased and reached the framework of a few weeks [10].

Table 1: Time estimation for prototyping process.

Action	Duration, h
Clay model acquiring	45 min
Drying in the oven	15 min
Digitizing with 3D scanner	30 min
Postprocessing	30 min
CAD modeling	10 h
3D printing	2h 24 min
Drying	45 min
Additional processing (dipping)	1 h
TOTAL	15h 45 min

4. CONCLUSION

Designing new ergonomic products today does not necessarily mean finding new technical solutions and breakthroughs, but occurs through a departure from conventional approaches and traditional materials and designs.
Application of Rapid Prototyping technologies in new product development as compared to the conventional approach, depending on the size of production can provide savings in the amount of 50 – 90% of used resources.
Making custom made ergonomic products using Rapid Prototyping technologies reduces costs and allows manufacturing of ergonomic parts in short period of time. This paper shows that using clay and the 3D scanner as a media for information transfer ("to get the shape right") saved about a month in CAD and physical prototyping iterations. Total time used for prototyping compared to few weeks or a month is much faster, cheaper, more accurate and ultimately better.
Nowadays technology of rapid prototyping has evolved to a level that is used in a wide range of applications for creating conceptual models, functional prototypes, finished products, tools, etc.
In the near future disadvantages such as high cost and the limited choice of materials will likely be removed thereby technology for rapid prototyping will get the opportunity to meet all the requirements set by the production in the various branches of industry.

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DESIGN CHARACTERISTICS IN SURVEILLANCE OF ERGONOMIC SAFETY AND EFFICIENCY OF PRODUCTION PROCESS

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Abstract: *Introduction of closed circuit television for surveillance of production process safety and efficiency in industrial facilities for processing metal, production of boilers, transformers, machine construction etc. represents a complex and demanding project task. Nature of the process and characteristic layout of machines, tools and equipment as well as lighting conditions in the production area do not allow the traditional implementation of video surveillance camera layout and mounting. Due to a large number of obstacles within the field of view, the application of traditional approach necessitates the installation of a large number of cameras which entails a larger number of digital recorders and greater hard disk capacity as well as an enormous increase of investment costs. Considering the interruptions in the field of view, the application of the classic design approach with megapixel IP camera technology results with the same problems we encounter in the application of technical solutions in analogous implementation. This paper analyses the methods of obtaining economically acceptable solutions for the surveillance of production process safety and efficiency in demanding interiors of metal industry production facilities.*

Keywords: surveillance, ergonomic safety, efficiency, production process

1. INTRODUCTION

Visual surveillance technology with electronic cameras has evolved from a need for monitoring processes in environments dangerous for people. During 1942, the company Siemens AG has, under the direction of Walter Bruch (later the creator of the PAL system), developed a closed circuit television system (CCTV) for the purpose of testing and monitoring the launches of infamous Nazi rockets V-2. After the end of World War II, the development of military industry for long - range missiles and later the American space programme has transferred the further development of this technology to United States which was the leader in application and development of closed circuit television up to the end of Cold War.

Correctly detected requirements and design elements of the video surveillance system will enable the required and accurate: *detection of persons, recognition of known*

persons and the possibility to identify the identity of unknown persons based on the video recording [1].

2. ELEMENTS AND APPLICATION OF CCTV

In any of the required fields of use, the closed circuit television system consists of the same basic elements. These are: camera, lens, device for storing and viewing video recordings, connection medium and monitor. The closed circuit television system, regardless of its area of application, is always subjected to the same physical laws which affect the qualitative results of its operation; display of optical image of required resolution on the monitor screen.

3. BASIC LAWS THAT GOVERN THE CCTV

The optical image of required resolution, displayed on a surveillance monitor screen is the end result of operation of all the elements which make the closed circuit television system. The term optical image implies a clear reproduction of objects that a system of lenses and mirrors creates from reflected, refracted or diffracted rays of light [2]. Definition of the term "required resolution" depends on the area of application of the closed circuit television [3].

The closed circuit television system, i.e. the video surveillance system (according to terminology used by security firms, police and the legislator in the Private Security Act, Law on Minimum Security Measures in Cash and Securities Operations), in public and private security is used for detection of persons in the surveillance area, Figure 1, recognition of persons, Figure 2 and identification of persons, Figure 3.

Figure 1: *Detection of persons in the protected area, a person or an object occupies at least 10% of the monitor screen height.*

Figure 2: *Display of a person occupies 50% of the screen height – known persons recognition is enabled.*

Figure 3: *Display of a person occupies 100% of the screen height – person identification is enabled.*

The conclusion is that the closed circuit television system, depending on the application, must meet certain requirements which define the size of the elements in the scene displayed on the screen and the resolution of the picture displayed on the monitor screen. The requirements for the size of the scene elements and the picture resolution depend on the functional application of the system. When the system is used for person identification, its elements must satisfy much higher technological requirements as opposed to when the system is used for detecting a presence of persons within the

protected area. Moreover, it is apparent that the size of the scene elements displayed on the monitor screen depends on the functional requirements.

4. CAMERA, LENS AND SCENE DIMENSIONS

The nature of laws of photographic optics is such that the combination of certain types of sensors and lenses of certain focal lengths determines the camera's horizontal and vertical field of view. These relations are shown on Figure 4. Field of view of the camera in horizontal and vertical plane can be determined on the basis of the following relation:

$$\frac{w}{W} = \frac{h}{H} = \frac{f}{d} \tag{1}$$

where: W – width of the recorded scene,
w – width of the optical sensor,
h – height of the optical sensor,
H – height of the recorded scene,
f – focal length of the lens and
d – distance of the camera from the recorded object.

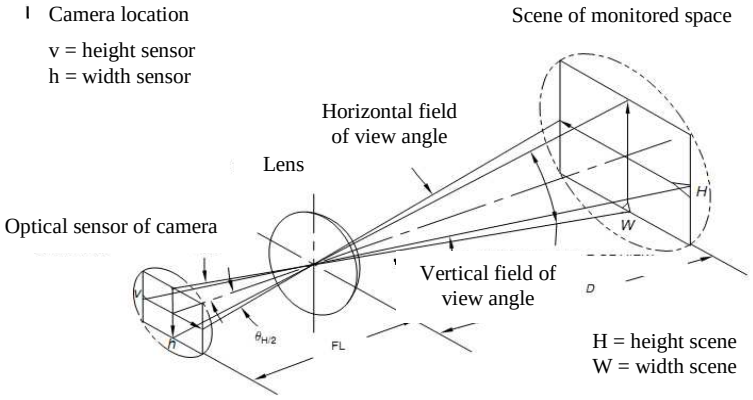

Figure 4: Camera's field of view, focal length of the lens and scene dimensions [4]

The mentioned relations of sensor dimensions and focal length of the lens speak about the dimensions of the scene that can be seen, but solely on the basis of these relations there is no information on the precise position of the plane within the scene where the scene elements will be the sharpest on the monitor screen. The plane within the scene where the elements are the sharpest is defined by a term depth of field. Debt of field represents the area which the lens displays sharply. It depends on three factors; aperture, distance of the scene elements and focal length of the lens [5, 6, 7, 8].

Each obstacle inside the camera's field of view requires an installation of an additional camera for monitoring the scene defined by the functional requirements of the system illustrated on Figures 1, 2 and 3. Camera in a closed circuit television system intended for increasing workplace safety and surveillance of production process efficiency can enable a detection of persons within a scene, recognition of persons within a scene or their identification. Single camera within the system can fulfil only

one of these three functions, in no way can it qualitatively fulfil all three functions at once.

5. DESIGN APPROACH TO POSITIONING CCTV SYSTEM ELEMENTS

Dimensions of a production facility which requires the implementation of a surveillance system for production process ergonomic safety and efficiency in metal and engineering industry is 130 x 50 meters, and the height from the floor to the roof beams is 12 meters. In this kind of buildings there is a movable crane at a height of 8 to 10 meters, which dynamically affects the camera's field of view along the entire length of the building. Along the middle of the production facility there is a marked 3 meter wide pathway for entrance and movement of persons and equipment, an workplaces and machines are arranged along the entire length of the object on the left and right side of the marked pathway. Welders' workplaces are for safety reasons separated by screens, as well as equally dangerous workplaces of grinders. Protective screens, because of their structural function, also interrupt the camera's field of view. Figures 5 and 6 illustrate the interior appearance and dimensions of a typical production facility [9].

Figure 5: *Interior of a production hall with a crane under construction*

Figure 6: *Interior of a functional production hall*

In these kinds of interior conditions the investor must ensure the surveillance of ergonomic safety and efficiency of production process by using an optimal number of closed circuit system elements which ensures cost effectiveness of the investment. For the purpose of surveillance of safety and efficiency of the production process the system must provide functionality at a level that is "more than detection, less then recognition". The minimal visual requirements for the investor consist of a need to detect the use of protective equipment in the production process and an insight into workspace occupancy and performance of activities at the workplace.

The closed circuit television system for this application does not have to enable recognition of persons or parts of personal protective equipment smaller then a safety helmet Due to a characteristic colour of the safety helmet with a visor, this type of a helmet can besides recognition by shape also be recognized on a person by a distinct colour which is different from all the other parts of protective equipment. The only installation position which ensures the smallest possible interruption of camera's field of view and the installation of the minimal number of cameras is above the factory crane, at a height of 12 m above the factory floor. "Fisheye" lens is a type of a lens that additionally increases the efficiency of a single camera's field of view, and its optical

spherical distortions will not decrease the surveillance performance of the system in this functional application of the closed circuit television system.

6. PURSUIT FOR ECONOMICAL SOLUTION OF THE PROBLEM

It is necessary to secure an economically acceptable and functionally efficient solution for the implementation of the CCTV system in the production facility of large dimensions and multiple interruptions in the line of sight. Determined dimensions of the building are: length 130 meter, width 50 meters, height from the floor to the roof beams 12 meters. Multiple interruptions in line of sight dictate the need for installing cameras under the roof beams. Regarding the width of the building, it is assumed that the use of a fisheye lens paired with a 1/2.5" optical sensor of 5 Mpx resolution will achieve the optimal coverage of 50 x 50 meters per camera. Whit this kind of coverage over a length of 130 meters we assume that the functional efficiency of the system could be insured with 3 cameras and their lenses. Camera's field of view (HFOV) for the known sensor dimensions and focal lengths can be calculated according to the following equations:

$$HFOV = camera\ distance * \frac{sensor\ diagonal}{focal\ length} \tag{2}$$

Since the distance of the camera (height of 12 meters) and sensor dimensions (1/2.5" sensor is 5.76 mm wide [10]) are known, required value is the focal length of the lens needed to cover a 50 meter wide area:

$$Focal_{length} = \frac{distance * sensor\ diagonal}{HFOV} \tag{3}$$

$$Focal_{length} = \frac{12 * 0{,}00576}{50} \tag{4}$$

$$Focal_{dulength} = 1{,}3824\ mm \tag{5}$$

When calculating focal lengths in photographic optics, values smaller than 1.4 mm and greater than 500 mm are considered unrealistic. Because of this the focal length value is selected from 1.6 mm and backward checked on the basis of HFOV formula for the field of view that this combination of sensor and lens will provide.

$$HFOV = 12 * \frac{0{,}00576}{0{,}0016} \tag{6}$$

$$HFOV = 43.2\ meters \tag{7}$$

On the basis of calculation we can conclude that a camera installed in the middle of the building at a height of 12 meters with a fisheye lens and focal length of 1.6 mm will cover a scene 21 meters wide to the left and right of the point of installation. This gives a satisfactory covered width of the building, since 4 meters from the edge of the building does not represent a space of vital interest for the investor. Considering that the lens projects a circular scene image onto the optical sensor (so called *circular fisheye*

lens), the scene also includes 43.2 meters on production hall length. Since the production hall is 130 meters long, for successful coverage of the entire hall length a total of four surveillance cameras will be needed. Cameras will be installed at a height of 12 meters at equal distances of 32.5 meters.

7. CONCLUSION

By applying an alternative approach in the search for a solution the requirement of the investor which at first sight requires a large budget for project realization can be accomplished by relatively modest means. Certainly, mitigating circumstance which enables the alternative approach is the level of functional application: "more than detection, less than recognition".

Closed circuit television can be successfully used in all areas where its implementation enables increased work safety levels and efficient allocation of scarce resources, as well as surveillance of processes in areas that are dangerous for people, surveillance of automated production processes and monitoring of work safety level and employee productivity.

When the same combination of optical sensors and lenses is used, we always get the same scene widths. When a lens of certain focal length is used in a combination with a sensor of larger or smaller dimensions, the scene width will not be the same. For the same focal length of the lens, sensors of smaller dimensions get a smaller optical picture of the scene, and accordingly the field of view, i.e. the width of the scene will be smaller.

The increase of scene width with the use of a larger sensor results with a proportionate increase of investment costs since larger sensors are more expensive and their lenses are in a higher price range. Investment in larger sensors is justifiable in cases when the scene width of an individual sensor replaces the total production process surveillance area covered by several smaller sensors.

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CONSTRUCTION FEATURES IN ERGONOMIC DESIGN OF USER INTERFACES

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Abstract: *In order for the user interface to be of acceptable ergonomic design and ready for use, it is necessary to observe the basic rules of design. In modern technology user interfaces can be found almost everywhere; in business application, software, web pages, mobile devices, personal computers, databases etc. When designing the structure of the interface we must define the basic structure in a way that defines the basic elements and/or system components. The basic function of the user interface is to facilitate dialogue, a communication between man and computer. Unlike the written word, the interface is not meant for continuous reading, but it is more of a dynamic framework foreseen by constant complex selection. The user interface is basically defined as a two way communication channel between man and computer. If we wish to expand this definition, we can then say that modern user interfaces use relatively intelligent technologies for achieving communication between man and computer.*

Key words: *construction design, ergonomics, user interface, web portal*

1. INTRODUCTION

To enable the users to communicate with the computer we have to develop a user interface which is also called “visual interface”. In order to make the communication as successful as possible, the user interface must be designed according to certain rules and recommendations [1].

Formerly computer screens were used only for displaying text that the user was typing on the computer keyboard. In the graphic user interface environment the screen itself becomes a data input device. It represents graphical objects with icons, and different data input / output devices with command buttons and scroll bars. By using a keyboard (or with a more direct pointing device like a computer mouse) the user manipulates with the selected objects on the screen. In this way the interaction between the user and software becomes direct. Instead of one way flow of information from the keyboard to the software and then towards the screen, the user communicates directly with the objects [2].

The goal of modern intelligent user interfaces is to bridge the existing problems of man and computer interaction by maximally adapting the user interface to the user and offering him new ways of communication with the use of ergonomic construction design.

2. USER INTERFACE

User interface is a way of interaction between man and computer through manipulation of graphic elements and accessories with a help of textual messages and notifications. User interface is used for controlling the computer, it can be used with input devices like the computer mouse, keyboard or a tuchscreen. In the present user interfaces the output device which visually displays numerous commands, as well as user actions, is the computer screen [3].

User interface comprises of three basic parts:

- Navigation mechanism determines the way in which the user will direct the requests towards the system, i.e. the way in which the user orders the system what to do (e.g. user selects a menu to get a window for product data input, and saves this data into a database),
- Input mechanism determines a way in which the user enters data into the system (e.g. a form with 5 empty field in which the user enters data about a certain person) and
- Output mechanism determines a way in which the system delivers data to users (e.g. printed reports, diagrams …).

The goal of ergonomically designed user interface is the implementation of an interface which is easy to use, has a nice appearance, and at the same time allows the user to perform a certain task with minimal effort and time. The basic problem with designing a user interface is a large quantity of information that a user interface must provide to the user, and not enough space for displaying this information on the computer screen. Most often we must use several screens, forms, pages to show all the information which complicates the user interface for the user; Figure 1 shows a graphic user interface for music production with multiple monitors [4].

Fig. 1: *User interface with multiple monitors*

2.1. Types of user interfaces

User interface is a basic interaction of a person with the computer. Over the course of history a larger number of systems was developed, from ones having only textual interfaces to ones with pictures, icons and sound elements. In modern computer science there are three main types of user interfaces; command line interface, text user interface and graphical interface [5].

2.1.1. Command Line Interface

In Command Line Interfaces (CLI), commands were entered via a keyboard into a provided frame, and the course and result of a given task was displayed on the screen. The performing of tasks was linear and foreseen for unitasking (simultaneous performance of a single task).

All Windows operating systems include an option for command line work on the computer. Sometimes even today command line interfaces are used for management of files, maintenance and inspection of the system, maintenance and inspection of computer networks and to work with files. Figure 2 shows a command line user interface in MS-DOS.

2.1.2. Text User Interface

Text User Interface (TUI) does not have a graphical display and it always uses textual representations of functions, but the usage of this type of user interface is closer to a graphical user interface than to a command line interface. Commands are selected among the existing elements within the interface. The concept of a textual user interface is more of an output type of interaction than an input type of a command interface. Textual user interfaces use texts, symbols and colours..

BIOS s an example of a text user interface which is used in every standard computer. It is a basic computer program which is run after the personal computer is turned on. Figure 3 shows a text user interface on the example of BIOS.

2.1.3. Graphical User Interface

Graphical User Interface (GUI) simplifies the use of programs by making all the function available within the user interface. A typical user interface uses windows, icons, plain and drop down menus, dialog boxes and similar elements. For performing a certain task within the graphical user interface we have to control the visual elements.

Today the graphical user interface is not used only on computers but also on various pseudo information technologies. The use of modern computers, mobile phones and similar devices is much simpler then in the time of the DOS operating system. Almost all the operating systems today have a capability to use graphical user interfaces and Figure 4 shows a graphical user interface of a modern operating system Windows 7.

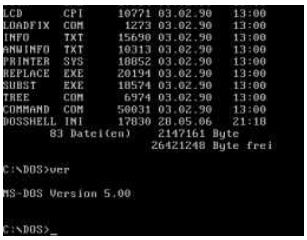

Fig. 2: *Command Line Interface*

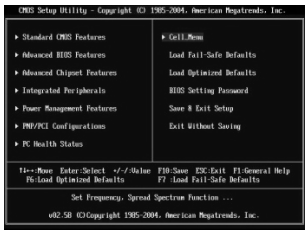

Fig. 3: *Text User Interface*

Fig. 4: *Graphical User Interface*

3. RULES FOR DESIGNING USER INTERFACES

User wants to control the computer and does not want to be controlled by the computer. The interface must enable the user to focus on the task at hand and he must be able to do it in an intuitive manner. User interface is a window into an application. Ergonomically we need to define an interface which does not require unnecessary actions from the user, i.e. the user must control the application with minimal effort. Furthermore, it is necessary to "hide" the technical details from less advance users. The application needs to be a layer above the computer and the operating system, enabling the user to interact with objects on the screen. User wants to control the objects on the screen in a way he does it in the real world [6].

The interface must progressively offer options. The most used options should be offered first and only then options which are used to a lesser extent. Only data pertaining to the user request should be displayed and all other data that distracts the user should be avoided. The most used data should be located at the beginning. Grammatical structure and choice of words stay in a linear language form in the entire application. Titles and chapters do not need to be changed if there are more of the same forms or tables.

The consistency of the interface gives a visual identity of service which thereby becomes more easily recognizable and accessible to users because a determined user perception of the service is being created. The consistency of the interface implies that all the visual information is organized according to an ergonomic design standard which was applied to all the screen displays, mechanisms of command and data entry have a limited set of options which were consistently used within the entire application and navigational mechanisms between individual tasks were consistently defined and implemented [7].

4. DESIGN FEATURES OF ERGO DESIGNED WEB INTERFACES

Concerning the comparison of ergonomic constructional design features, the following will examine websites of three polytechnics in Croatia; Polytechnic in Slavonski Brod, Varazdin and Vukovar. Present analysis has shown that the most important thing for each polytechnic is for their website and preparatory phase to be as simple as possible, understandable and transparent, regardless of the project complexity.

4.1. Polytechnic of Slavonski Brod

The Polytechnic of Slavonski Brod has a high quality web page consisting of various creative and informative segments where besides a classic home page and a page about the polytechnic, and all the other basic information, there is also a weather forecast for the current day and two days in advance. Another positive thing is that the website displays the number of currently active visitors and members. When visiting the website, visitor is immediately encountered by current news and there are banners offering links to a foreign language school, professional training and similar, Figure 5 [8].

Students can access information about student exchange, student projects etc. with just one click of a mouse. The biggest drawback of the analysed website is poor visibility and accessibility of lecturers personalised web pages.

4.2. Polytechnic of Varazdin

This is not an old polytechnic but it is constantly being developed with great success. New innovation which has involved into a strategy for this polytechnic is the development of web pages, which are better, of more quality and easier to use for students, professors and random visitors alike. Besides the basic information about the institution, they offer separate pages for all the courses which can easily be opened on the first third of the home page [9].

Furthermore, bellow these links there are also easily accessible links to additional contents like: ISVU, WEBmail, Moodle, Claroline, DreamSpark, Filesender, Xica CAP, CARNet. Another positive thing is that each notification on the home page has an indication of the course to which it refers beside it. A shortcoming of this website can be noticed as certain monotony in the choice of colours, since prevailing colours are tan and cool, and a lack of other informative and interesting contents outside of the main scope of the polytechnic. If we compare it to the website of Polytechnic of Slavoski Brod, there is a lack of interesting information like the weather forecast and there is also no easy way to access the personalized web pages of individual lecturers.

4.3. Polytechnic Lavoslav Ruzicka in Vukovar

Perfectly organized and accessible website of Polytechnic Lavoslav Ruzicka in Vukovar leaves an excellent impression. Here we have present all the components missing in previously analysed web pages of Croatian polytechnics. On the top of the home page we can see alternating motivational phrases like: “Dare to know”, “Knowledge is power”,”We are not learning for school, but for life”, “Many know a lot, but nobody knows everything”, “Repetition is mother of all knowledge” [10].

The courses are easily visible and all the information about the desired course can be accessed by a single click of a mouse. News and latest lectures by well know lecturers or guest professors are clearly notable. Photo gallery has photos which give great insight into events that made a mark on Polytechnic Lavoslav Ruzicka in Vukovar. Photos are being rotated on the home page, among them is a photo of exterior of the polytechnic with a bust of the first Croatian Nobel Prize recipient Lavoslav Leopold Ruzicka. Therefore, this is a perfect example of how with a relatively more effort, ergonomic innovation and imagination we can create a better result. Not much is needed in order for one website to be better than another, it is enough to implement just a few details which are not present in other web pages and which contribute to the quality.

Fig. 5: *Polytechnic of Slavonski Brod website*

Fig. 6: *Polytechnic of Varazdin website*

Fig. 7: *Polytechnic of Vukovar website*

5. CONCLUSION

Websites represent an important part of the entire impression of a certain institution, and accordingly each institution tries to have the best possible web portal. Construction features of web pages of Croatian polytechnics differ on case to case basis. Although they generally offer the same information and links needed for giving quality information to the interested, it is certain that there are significant differences in first appearances, the way the pages ere designed, availability of all the required information and the ease of navigating them.

The user interface is much more than just windows, menus and icons. It includes a complete user experience of using the program, starting from installation, start up speed, way it is integrated with the operating system, and up to usability of documentation and error messages. A good user interface is of extreme importance, actually, it largely influences the successfulness of the program. Although construction design and technology of the program ultimately determine its total capabilities and speed, from the users point of view, the user interface is the program.

Thanks to continuous research, graphical user interfaces are continuously developing, and since almost all the novelties which contribute to simpler and more ergonomic work have been accepted by the users, the user interface will continue to develop primarily in the direction of physical interaction between users body movements and command actions directed towards the computer.

The example of Polytechnic of Lavoslav Ruzicka in Vukovar web pages is much more positive than other two compared polytechnics with regard to its comprehensiveness and positive first impression. Furthermore the qualitative characteristics of ergonomic approach to construction design are of exceptional importance in respect to the simplicity of navigating and sorting of information according to priority.

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RELATIONS BETWEEN THE TYPE OF LOCOMOTIVE OR MOTOR COMPOSITION AND DISTURBANCE OF ENGINE DRIVERS CAUSED BY TRAFFIC NOISE

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Abstract:

Prolonged exposure to high intensity noise results in strong psychological and physiological effects and hearing loss which can lead to subjective feelings of disturbance from cognitive perception of engine drivers and reduced working capacity. Apart from permanent health problems, reduced speech intelligibility due to broadband noise exposure results in unreliable communication in driver's locomotive which can significantly affect the safety management of the train by increasing the perception-response time of drivers to sounds from traffic and working environment, causing increased difficulty of the engine drivers' task according to open dynamic Fuller TCI model of "task demand – driver's capability". The paper presents the subjective assessment of the respondents' own state of hearing impairment, the effect of different noise sources in the locomotive or motor composition, as well as the subjective impression of the quality of speech intelligibility in communication between drivers and/or dispatchers. Relations between percentage occurrence of specific causes of temporary or permanent subjective feelings of disturbance in relation to type of locomotive or motor composition have been researched. The correlations of the respondents' subjective ratings to the auditory effect of noise; TTS and tinnitus as well as possible symptoms of vibroacoustic disease in relation to exposure time defined by the working age of male respondents from the Republic of Croatia have been also studied.

Key words: *engine drivers, noise, subjective disturbances, TTS, tinnitus, vibroacoustic disease*

1. INTRODUCTION

According to Sumpor et al. [1] research from year 2010, while operating a locomotive or a railcar the engine drivers are exposed to the action of several simultaneous factors of disturbances from the traffic and working environment. "Continuous and periodical audible traffic noise in locomotive drivers cab" is the first among dominant ergo-assessment disturbance factor [1], evaluated by using the index of importance I_V on a random sample of 50 engine drivers, all from the Republic of Croatia. According to the open dynamic TCI model by Ray Fuller [2] the factors from a "human factor" group also affect the drivers' capability as well as their task demands, while factors from the

groups labelled "traffic environment" and "transport means" are input variables in TCI model. In general, noise affects both health (physical and psychological) and behavior. The effects of noise on human hearing are well understood, but the effects of noise on other aspects of human health are less understood. Noise can cause annoyance and aggression, high stress levels, skin infection, respiratory tract infections, tinnitus, hearing loss, headaches, mental and neurological disorders etc. Apart from permanent health problems, reduced speech intelligibility, due to broadband noise exposure, results in unreliable communication in driver's locomotive. This can, in turn, significantly affect the safety management of the train by increasing the perception-response time (*PRT*) of engine drivers to sounds from traffic and working environment, causing increased difficulty of the engine drivers' task according to open dynamic Fuller TCI model of "task demand – driver's capability".

2. THE INFLUENCE OF THE NOISE EXPOSURE AND THE RESULTS OF THE RESEARCHING

Engine drivers are exposed to significant noisy environment that includes broadband noise and vibrations. This can result in appearance of vibroacoustic disease symptoms, tinnitus, temporary threshold shift (*TTS*), permanent threshold shift (*PTS*) and compromise speech intelligibility between drivers staff.
Vibroacoustic disease *(VAD)* is a noise-induced, whole-body pathology, of a systemic nature, caused by excessive and unmonitored exposure to low frequency noise (*LFN*). VAD has been observed in LFN-exposed professionals, such as aircraft technicians, commercial and military pilots and cabin crewmembers, ship machinists, restaurant workers, and disk-jockeys [3]. It evolves over long-term noise exposure, in years, and can lead to severe medical conditions, such as cardiac infarcts, stroke, cancer, epilepsy, rage reactions, and suicide [4]. Studies have shown that environments with high-intensity sound over 110 dB, combined with low-frequency sounds below 100 Hz, place people at high risk of developing VAD. This kind of sound and infrasound exists also in daily working conditions of engine drivers at the Croatian railways. The possible existence of known and evident symptoms of this chronic, progressive, cumulative, systemic disease was investigated on a random sample of 32 engine drivers and the results are presented at Fig. 1 and 2.

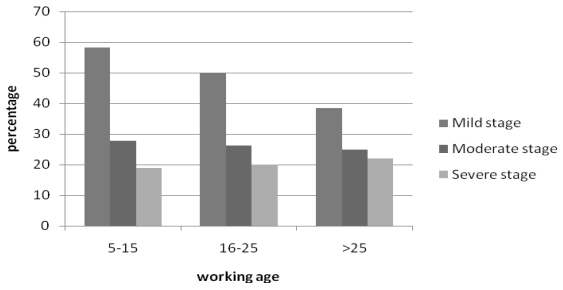

Figure 5: Percentage of the symptoms occurrence according to the VAD stages in relation to the drivers working age

From Fig. 1, a slight increase of the percentage occurrence of VAD symptoms for severe stage in relation to the drivers working age is visible.
According to Branco and Alves-Pereira, the stages of VAD are as follows:
Stage 1 - MILD (1-4 years of exposure to noise): Slight mood swings, indigestion, heartburn, mouth/throat infections, bronchitis;
Stage 2 - MODERATE (4-10 years of exposure to noise): Chest pain, definite mood swings, back pain, fatigue, skin infections (fungal, viral, and parasitic), inflammation of stomach lining, pain and blood in urine, conjunctivitis, allergies;
Stage 3 - SEVERE (> 10 years of exposure to noise): psychiatric disturbances, hemorrhages (nasal, digestive, conjunctive mucosa) varicose veins, hemorrhoids, duodenal ulcers, spastic colitis, headaches, severe joint pain, intense muscular pain, neurological disturbances.

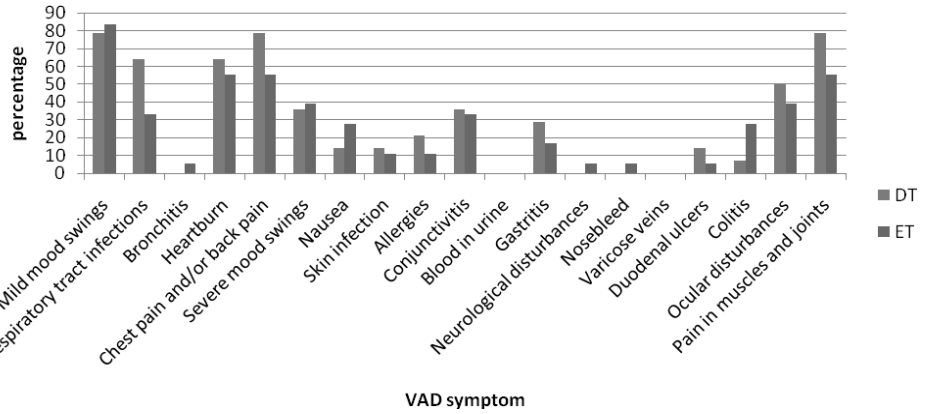

Figure 6: Percentage of the VAD symptoms occurrence according to the prevalent type of tractions (DT – Diesel Traction, ET – Electric Traction)

Engine drivers are also prone to tinnitus – an ear buzzing, which is considered as a condition rather than a disease, induced by, among several other possible factors, exposure to noise which damages hair cells in the inner ear. Auditory fatigue is defined as a temporary loss of hearing after exposure to certain levels of sound. This results in a temporary shift of the auditory threshold known as Temporary Threshold Shift *(TTS)*. Short exposure to noise of about 80 dB SPL results in one-minute long TTS. TTS of 8 hours is a result of sufficiently long exposure to noise and can be physiological fatigue with appearance of tinnitus in the beginning, while recovery takes about 16 hours. TTS of longer duration is a pathological fatigue, and recovery is somewhat linear by few dBs per day. The damage can become permanent, with condition known as PTS (Permanent Threshold Shift), if sufficient recovery time is not allowed before another high-level noise exposure takes place. PTS is expected in exposure to noise levels higher than 145 dB SPL for one second, while cumulative exposure longer than 2 years in environment with noise levels higher than 90 dB SPL will result in threshold shift of 20 dB. Subjective sensation to this audible noise disturbances according to working age and to the prevalent type of tractions of engine drivers are presented at Figures 3 and 4.

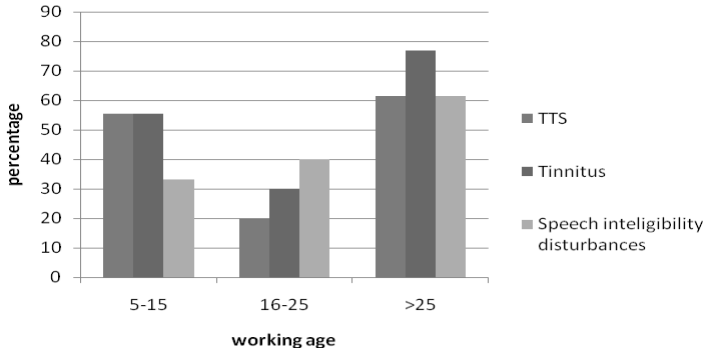

Figure 7. Percentage of the audible noise disturbances in relation to the drivers working age

Speech intelligibility is the percentage of speech that a listener can understand or the clarity of a speaker's utterances. Working environment of the locomotive interior can be congested with different kind of noise and sound from train information systems which can decrease speech intelligibility between engine driver staff and it can result in deterioration of driving safety.

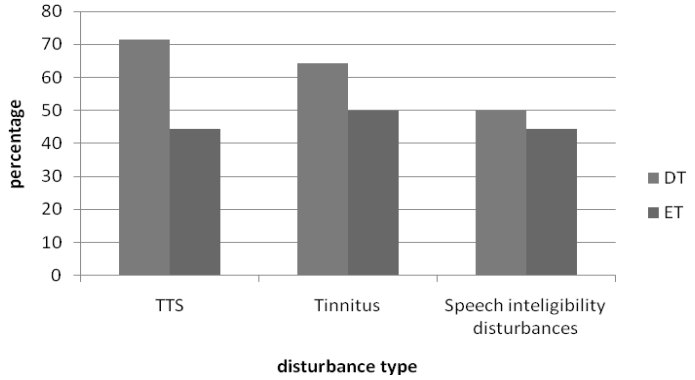

Figure 8. Percentage of the audible noise disturbances in relation to the prevalent type of tractions

According to Sumpor et al. [1], Diesel locomotive is subjectively the noisiest by the average grade $\bar{o}$, for results shown in Table 1. Average grade $\bar{o}$ for the intensity of subjective disturbances for n = 50 respondents is calculated according to following expression:

$$\bar{o} = \frac{1}{n} \cdot \sum_{i=1}^{n} o \qquad (1)$$

The respondents have assessed the subjective disturbance with grades from 1 to 4, grade 1 being equivalent of the maximum intensity of subjective disturbance.

Table 1: Ergo-assessment of the working ambient of the locomotive cab for three load factors

		$\bar{o}$ for subjective experience of disturbance in respondents							
Type of locomotive or motor composition		electric-motor composition		electrical locomotive		Diesel locomotive		Diesel motor composition	
Traffic flow for sake of transport		only passengers		freight or passengers		freight or passengers		only passengers	
Sample of respondents		31	50	31	50	31	**50**	31	50
visibility	ō	3.5	3.5	2.5	2.7	1.0	**1.0**	3.0	2,7
intensity of severity of operation		3.5	3.4	2.5	2.7	1.2	**1.2**	2.8	2,7
intensity of audible noise disturbance		3.6	3.7	2.5	2.6	1.1	**1.1**	2.8	2,6
Σ ō / 3		3.53	3.53	2.50	2.67	1.10	**1.10**	2.87	2.67

Source: Sumpor et al. 2010 [1]

Except for train noise in general, many kinds of different sources producing occasional sounds also exists while driving. Some of them are related to train security systems such as "dead-man" function, AS (Auto Stop device) tone, locomotive horn or door signal, while the others are related to the specific operating mode such as sound of brakes' squealing, compressor operation or compressor unloading. The subjective assessment of the respondents to disturbance caused by such sounds is presented in Fig. 5.

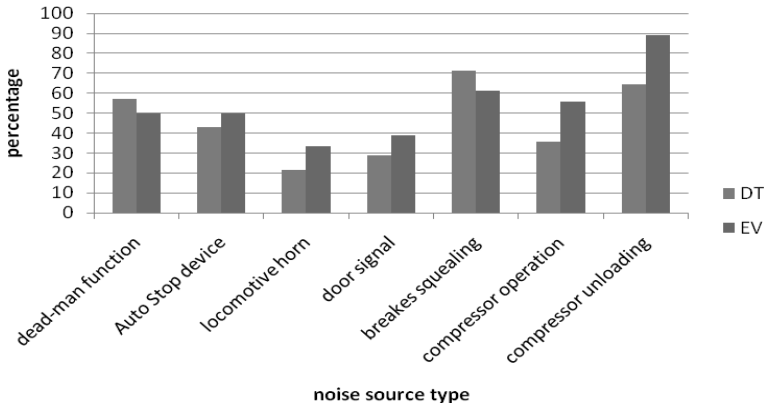

Figure 9: Percentage of the occasional noise source disturbances according to the prevalent type of tractions

3. DISCUSSION AND CONCLUSION

In this investigation on a randomly chosen sample of 32 male engine drivers from the Republic of Croatia, no firm evidence of respondents' subjective ratings to the auditory effect of noise; TTS and tinnitus, as well as symptoms of vibroacoustic disease, in relation to exposure time defined by the working age of respondents has been found.

Although the increase of working age reduces the number of respondents with mild stage and moderate stage VAD symptoms and increases the numbers of respondents with severe stage VAD symptoms (Fig. 1), much more respondents with severe stage VAD symptoms in all observed age groups have been expected. There are no noticeable differences in subjective disturbances of engine drivers according to classification in groups of prevalent type of tractions (Fig. 2). However, this study has demonstrated increased percentage occurrence of subjective disturbances (TTS, tinnitus) and reduced speech intelligibility from cognitive perception of engine drivers that drive Diesel locomotives, Diesel motor compositions and Diesel shunting locomotives, in relation to electric–locomotive and electric–motor composition drivers. It is also evident that all three types of disturbances are the most common in the oldest group of respondents (Fig. 3), as well as at Diesel-type engine drivers (Fig. 4) These new results, compared with the results of previous research which has demonstrated that the Diesel locomotive was subjectively the noisiest from cognitive perception of engine drivers, indicate the need for interior noise assessment of Diesel locomotive while driving, in relation to another type of locomotive or motor composition. To better understand the influence of occasional noise sources while driving, their spectrum must be also investigated in the further research. To come to firm conclusion regarding relationships between percentage occurrence of some researched factors of disturbance and the type of locomotive or motor composition, it would be necessary to significantly increase the number of randomly selected engine drivers and undertake thorough audiological survey.

ACKNOWLEDGEMENTS

The authors express their appreciation to all respondents who have voluntarily contributed in this research.

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PROCEDURE FOR CORRECTION OF LIFTING TASK POSTURE FOR INJURY PREVENTION

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Abstract

In order to keep lifting task execution most effective and safe, lifting execution should be properly evaluated and designed. Biomechanical analysis protocol is used for the purpose of identifying posture geometry deviations, spinal stability and lifting task settings. Consequent lifting attempts have been performed in iterative procedure of relevant biomechanical variables monitoring used to suggest immediate corrections on lifting task execution, in order to prevent risks of lumbar spine injury. Analysis of lifting task posture and estimated spinal stability can be employed with objective to detect injury risks and provide immediate correction of lifting task implementation, which is considered as preventive.

Keywords: *posture geometry, safe lifting, optimal lifting, lifting task correction*

1. INTRODUCTION

Studies have been focusing on specific objective to explain and understood spinal mechanisms and response to different cases that have been studied, as well as spinal stability. These studies have in common the objective to reach complete and thorough understanding on how spinal mechanism reacts, but with diverse approach. Some have been focusing on spinal stability [1-7], understanding of lumbar spine mechanism [2, 4, 5, 7- 10], estimating [11, 12] and determination of spinal loads during various activities [13-20], or even spinal structural behavior in motion [21-23]. Recommendations from extensive exploration of spine and its mechanisms are foundation for ergonomic purposes, where achieved knowledge and understanding of impact on spine caused by external conditions plays important role in lumbar spine health preservation.
Movements in material handling tasks are not proper neither symmetrical, therefore, main objective should be addressed to determination of optimal lifting task execution, in order to avoid conditions and circumstances that lead to nerves irritation, spinal segments and ligament or muscle tissue damage. That objective may provide feedback on risky inter spinal movements and deformations, as a consequence of external load reduced on spinal segments and structures. Instead of extensive literature overview on spine performance and injury etiology, our objective is to explore spinal load changes as

consequences of the way the worker handles the cargo, in order to reach a conclusion which lifting technique is most appropriate for assigned task, for every single worker.
Focus of this paper is addressed at estimation of optimal lifting task execution parameters that can minimize lumbar spine injury risks caused by irregularities in diverse lifting task conditions and circumstances. Furthermore, every worker should use obtained guidelines to correct and improve his manual handling skills with objective to minimize lumbar spine risks, with perhaps higher effectiveness.

2. METHODS

2.1. Experimental design overview

The in vivo experiment will be described briefly, as data was collected during lifting task execution attempts for healthy, asymptomatic male (23 yr., 1.7 m, and 75 kg), in further text simply Subject.
Trial consists of consecutive attempts of lifting the empty box (50cm high, 40cm wide and 50cm long) without any kind of handles, from the floor back to starting position, defined as standing upright. Box is intentionally left empty with objective to explore lifting technique consequences on spinal posture and load changes, but the box size is selected so it can become an obstacle to the proper lifting execution. It should be mentioned that experimental data acquisition restrictions influenced the choice of smaller box size than intended to be used, since there is known problem with markers disappearance in most MOCAP acquisitions. Prior to lifting task execution, subject was instructed on lifting objective in order to enable collecting of comparable results, with intent to adjust lifting technique according to observed changes.
In first attempt Subject has to perform the task spontaneously, while in any following attempt Subject should follow instructions given according to biomechanical analysis results.
Protocol for biomechanical analysis was designed in BTS Smart Analyzer software in order to enable appropriate biomechanical analysis of monitored variables as well as recommendations based on obtained results.

2.2. Evaluation criteria

As literature overview indicates, several possible criteria can be selected in order to estimate spinal injury risks, but as most comprehensive authors have identified spinal stability. Although the consensus on lumbar spine stability definition is not present [1], authors consider it as fine-tuned neuromuscular system coordination of the lumbar spine mechanism, provoked by posture and load parameters, in order to ensure controlled spinal segments motion. Lack of adequate lumbar spine stability mechanism response represented as involved muscles co-activation will cause variation of lumbar spine torque, which can indicate that stability of lumbar spine is compromised, revealing potential to injury. Magnitude of applied load is considered to be inside recommended margins, thus this notion does not certify that injury risks are not present.
Biomechanical analysis protocol allows that 3D moments and forces can be estimated, but available data acquisition procedure lacks in tracking of detailed and fine geometry changes for closely positioned markers, needed to determine exact change for each of lumbar spine segments, as important factor [21-23]. Protocol offers data of forces

components that coincide with fixed coordinate system, but their conversion into axial and shear forces is dependent on each spinal segment spatial position determination. Since analysis focus is on estimation of human factors that are possibly affected by lifting subject-object interactions in symmetric lifting tasks, most important results can be expected in sagittal plane. Thus, shear and axial load could not be considered as reliable variables, so as one of most appropriate variables for purpose of this paper is nominated lumbar spine moment in L5/S1 joint, for flexion and extension in sagittal plane.

2.3. Data acquisition

Data acquisition was made by an 8 IR camera BTS Elite system (Italy) at 100 Hz, with passive reflective markers used and placed on subject body as shown on Fig. 1, which represents simplified wireframe model of passive reflective markers layout positioned on specific anatomical places, with an explanation of abbreviations on the right side.

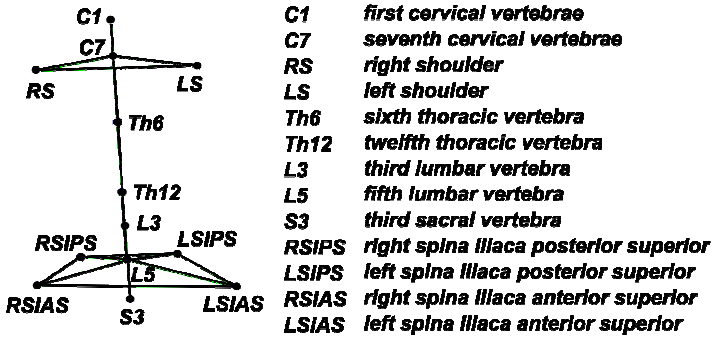

Figure 1: Wireframe model of passive reflective markers layout

After the first lifting attempt was performed and relevant data have been acquired, protocol for biomechanical analysis was designed in BTS Smart Analyzer software, in order to enable appropriate lifting technique correction and improvement through appropriate biomechanical analysis. Designed protocol consists of vectors of 3D forces and torques for each marker position. In any other consequent trial designed protocol was employed to obtain required results overview.

3. RESULTS

Data acquisition has been successfully completed for several consecutive trials, starting with initial one as starting point. As described earlier, after the data acquisition, data processing through analysis protocol in BTS Smart Analyzer enabled changes overview of lumbar spine moment at L5/S1, which is shown in Fig.2 for first, initial trial while Fig.3 represents results of best performed trial after several steps of corrections. Of course, even the best moment curve is not the best absolutely, since the box size and its geometry caused difficulties in handling task, but despite, it can be improved even more.

Results of lumbar spine moment's changes presented in Fig.2 and Fig.3 are time dependent, which enables opportunity to directly track and compare changes according

to lifting task phase. It is shown that the execution time was very similar, but the line chart indicates important differences in task execution parameters. Moment curve slope and moment values for specific time points will be used as lumbar spine moment curves comparison variables. Positive moment values is related with extension activity of spine while negative corresponds to flexion, where zero value is identified as neutral position of spine segments during upright standing.

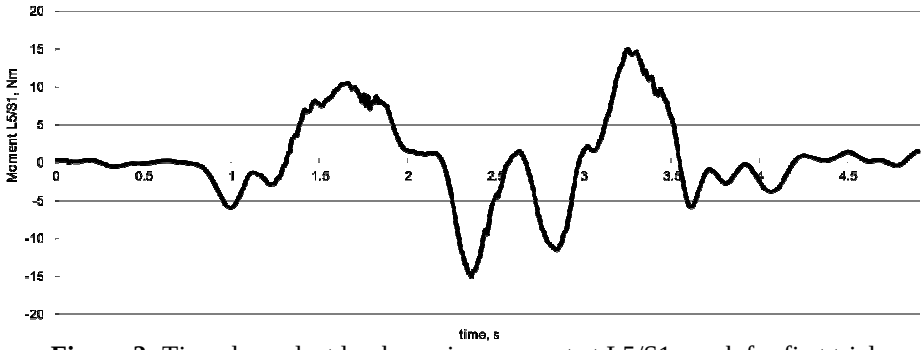

Figure 2: Time dependent lumbar spine moment at L5/S1 graph for first trial

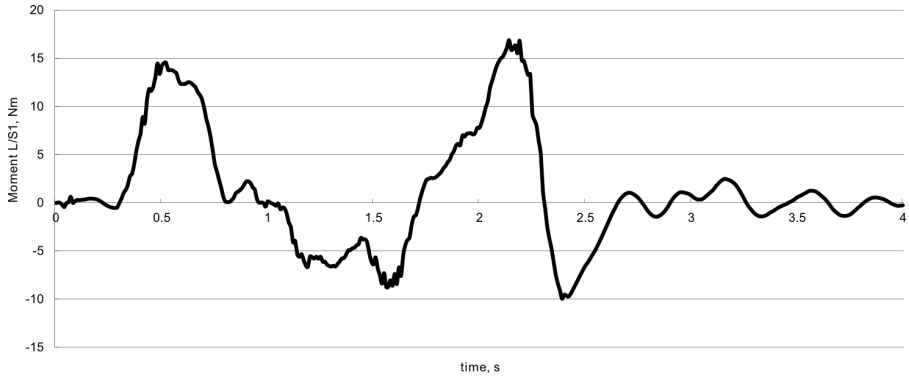

Figure 3: Time dependent lumbar spine moment at L5/S1 graph for best trial

In comparison on presented results one should pay attention to several key differences. As first one is higher magnitude of lumbar moment in extension phases while lower in flexion in Fig.3 comparing to Fig.2. This is considered as improvement since this means that extension contraction is improved in order to stabilize spinal segments making it stiffer, so the oscillations have smaller amplitudes, but still not perfect and consistent. Lower flexion moment magnitude although unstable with plenty of small oscillations, means that low back was not so flexed, or evidently less than at first, but can be improved from stability point of view. It should be remembered however that box size and its geometry is limiting factor to optimal lifting circumstances. The second important improvement is less steep curve in extension with box to upright position, which is recommended [17, 18]. Observed small oscillations of moment in Fig.3 can be explained and caused by accumulated fatigue during consecutive trials.

4. CONCLUSION

This paper presents direct procedure for lifting technique improvement by utilization of lumbar spine stability criteria as most comprehensive, in order to prevent injury interpreted through changes of lumbar spine moment in sagittal plane. As a result, recommended lifting posture and task execution parameters may arise from iteration of analyzed lifting trials, which can be applied as lifting task skills correction procedure. Mentioned iteration of assigned lifting executions, or material handling in general, implies that personal abilities and skills together with external loads provoke individual spine response which should be optimized. During iteration of lifting executions which is monitored by motion capture system that can recognize changes in spine geometry and kinematic data, obtained values for monitored variables can indicate favorable lifting parameters. This is important since this should affect lifting posture and technique, without very thorough biomechanical modeling.

ACKNOWLEDGEMENTS

This work was funded from scientific program 120-1962766-3109 by the Ministry of Science, Education and Sports of the Republic of Croatia.

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A METHOD OF LOADS ASSESSMENT IN THE KNEE JOINT FOR ERGONOMIC PRACTICE

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Abstract

Many studies have been published about spinal loads during various work activities, but few of them have looked at the knee joint loads. This study proposes a method of assessment of knee joint load, which allows a rapid estimation of the knee joint loads. A measurement of ground reaction forces and a recording of trajectories of characteristic points on the knee joint have been performed while walking on a flat surface and during stair descent, using the BTS-Elite system and Kistler force platform. 3D coordinates of the marked points, 3D components of ground reaction forces, and coordinates of their respective points of application have been the input data for calculating the knee joint centre, the loads in the medial and lateral compartments of the knee joint, the ligament loads and the total knee load.

Keywords: *knee joint load, walking, stair descent*

1. INTRODUCTION

During work activities, people take various body postures and move in different ways. The human gait is the simplest and the commonest movement, yet many studies have been published about gait analysis [1, 2, 3]. These studies used the Davis protocol, which requires 22 reflective markers attached on a human body, and an inverse dynamic approach to the estimation of forces in human joints.
Since many people suffer from knee damage and pain during walking at work, this study aimed at reaching a better understanding of the effect of walking on the knee joint load. A practical method of knee joint load assessment, which requires only four reflective markers attached on a human body, has been proposed.

2. METHODS

The methods of gait analysis presented in previous papers [4] have been adapted and used for the assessment of knee joint forces. The proposed method provides an

assessment of knee joint forces in frontal and sagittal planes only when the foot and the force plate are in contact (stance phase). For the sake of simplification, the influence of acceleration during normal speed walking was neglected. Four reflective markers were attached to the characteristic points on the recorded leg: two markers on the lateral and medial side of the knee and two markers on the lateral and medial side of the ankle joint. Recordings of marker trajectories were performed during walking on a flat surface and during stair descent, using the BTS Elite system with eight CCD cameras. The height of each stair was 12 cm. The reference coordinate system was fixed with respect to the laboratory. The x axis of the reference system coincides with the direction of progression and the y axis is the vertical axis. One vertex of the rectangular Kistler plate was the origin of the coordinate system. The ground reaction forces and the location of points of force application were measured using the Kistler force plate. The centres of knee and ankle joints were calculated using 3D coordinates of markers located on the lateral and medial side of the joints. The method was intended to provide an analysis of knee joint forces in the sagittal plane (0xy plane) and in the frontal plane (0yz plane). Figure 1 shows a simplified representation of the knee joint centre, ground reaction forces and their point of application in the frontal and sagittal plane.

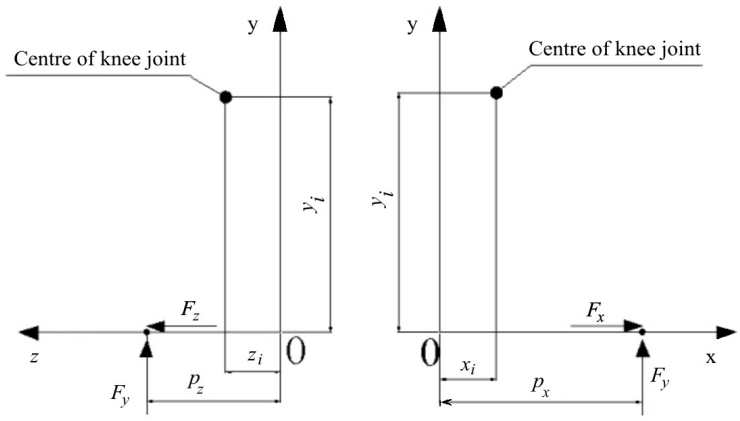

Figure 1: Knee joint centre, ground reaction forces and their point of application in frontal (0yz) and sagittal plane (0xy)

According to Figure 1, the moment M_z in the sagittal plane was calculated as:

$$M_z = F_y \cdot (p_x - x_i) + F_x \cdot y_i \quad (1)$$

where x_i is the coordinate of knee joint centre in the movement direction, y_i is the coordinate of knee joint centre in the vertical direction, F_x and F_y are ground reaction forces in x and y direction, and p_x is the x coordinate of the point of force application. The muscle force of quadriceps and gastrocnemius F_m depends upon M_z and the bicondylar knee width w, and was calculated according to the literature [4]:

$$F_m = \left| \frac{M_z}{2.69w} \right| \text{ if } M_z < 0 \quad (2)$$

$$F_m = \left| \frac{M_z}{3.18w} \right| \text{ if } M_z > 0 \quad (3)$$

The knee joint load (articular load) was calculated as:

$$F_s = F_y + F_m$$

where F_y is the vertical component of the ground reaction force. The moment M_x in the frontal plane was calculated as:

$$M_x = -F_z \cdot y_i - F_y \cdot (p_z - z_i) \quad (4)$$

where z_i is the coordinate of the knee joint centre in transversal direction, y_i is the coordinate of the knee joint centre in the vertical direction, F_z represents the transversal components of ground reaction force (in z direction) and p_z is the z coordinate of the point of force application.

In the frontal knee plane, the articular load F_s, the ligament loads and the muscle forces are in balance during walking. The articular load F_s is divided into vertical loads F_{lm} and F_{ll} which act in the medial and lateral compartments of the joint. These compartmental loads are taken to act at distance $w/4$ from the midline of the knee (Figure 2). Collateral ligament loads F_{cm} and F_{cl} are incorporated for stability, when the moment M_x reduces the load in either compartment to zero.

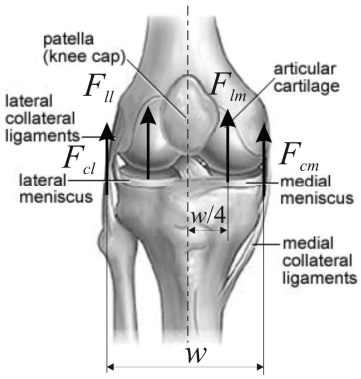

Figure 2: Knee in frontal plane

In the frontal plane of the knee, the moment M_x and the articular load F_s may be written as:

$$M_x = -F_{lm} \cdot \frac{w}{4} + F_{ll} \cdot \frac{w}{4} \quad (5)$$

$$F_s = F_{lm} + F_{ll} \quad (6)$$

The equations (5) and (6) represent a system of two equations with two unknown values: F_{lm} and F_{ll}. If either compartment load is found to be less than zero, then the adjacent collateral ligament is considered to take a load sufficient to maintain the integrity of the joint, and the negative load is reset to zero, i.e.:

$$\text{if } F_{lm} < 0, \text{ then } F_{lm} = 0 \text{ and } M_x = F_{ll} \cdot \frac{w}{4} - F_{cm} \cdot \frac{w}{2} \quad (7)$$

$$\text{if } F_{ll} < 0, \text{ then } F_{ll} = 0 \text{ and } M_x = -F_{lm} \cdot \frac{w}{4} + F_{cl} \cdot \frac{w}{2} \quad (8)$$

where F_{cm} and F_{cl} are medial and lateral collateral ligament loads.

In either case the knee joint load could be calculated as:

$$F_s = F_y + F_m + F_{cl} \text{ or } F_{cm} \quad (9)$$

3. RESULTS

The method was performed on one female participant (m = 62.25 kg, h = 172 cm, w =11 cm) during walking on a flat surface and during stair descent [5]. During stair descent, the Kistler plate was placed on the lowest stair. The recorded data were processed and the walking trials with no contact of the entire foot with the force plate were rejected. Ground reaction forces were normalized with the body weight (F/G). Figure 3 and 4 show trajectories of the knee joint centre and ground reaction forces as a function of the duration of foot-plate contact.

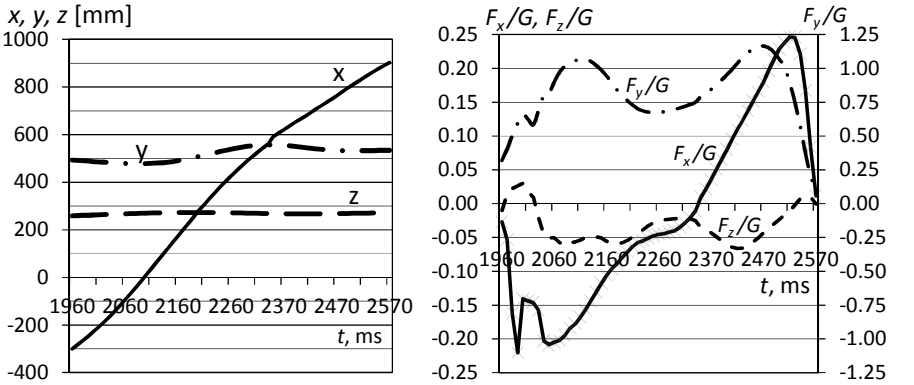

Figure 3: Flat surface walking – x, y and z coordinates of knee joint centre during contact of foot with the force plate, and normalised x, y and z components of ground reaction force as a function of duration of foot-plate contact

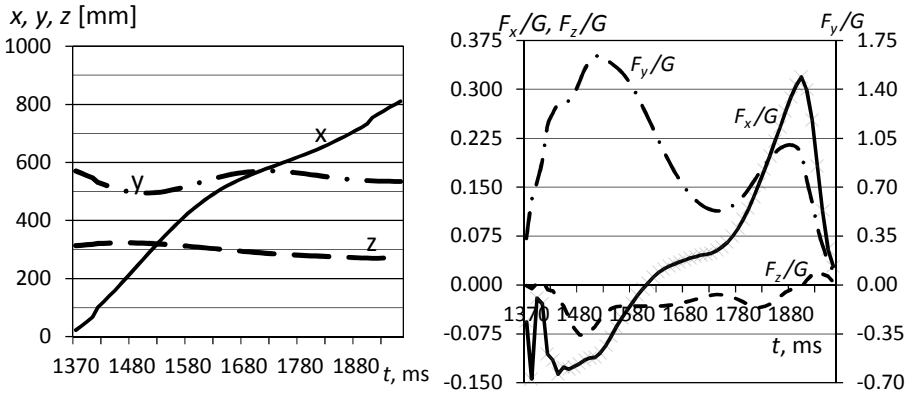

Figure 4: Stair descent – x, y and z coordinates of knee joint centre during contact of foot with the force plate, and normalised x, y and z components of ground reaction force as a function of duration of foot-plate contact

The load sharing between the medial and lateral compartments was computed using the equations (5) and (6). Collateral ligament load is incorporated for stability when the moment M_x reduces the load in either compartment to zero.
Figures 5 and 6 represent computed normalised forces in the medial and lateral compartments of the joint, normalised collateral ligament load calculated according to equations (7) and (8), and the total knee load during contact of the foot with the force plate determined from equation (9).

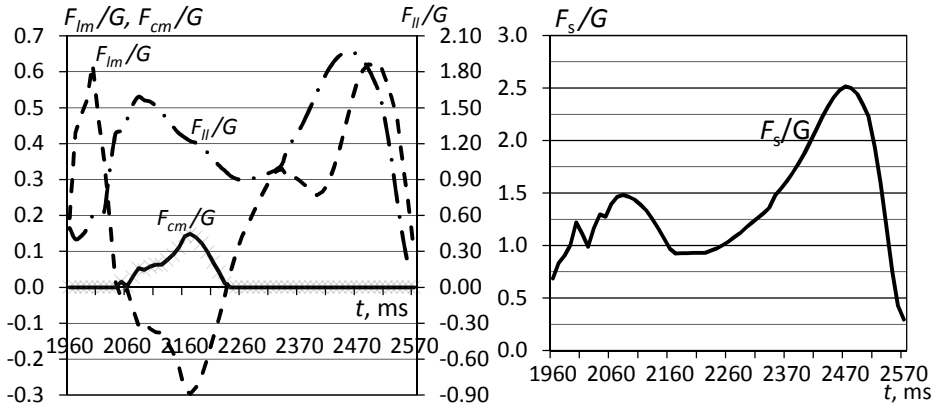

Figure 5: Flat surface walking – normalized forces in the medial and lateral compartments of the joint, normalised collateral ligament load and normalised total knee load as a function of duration of foot-plate contact

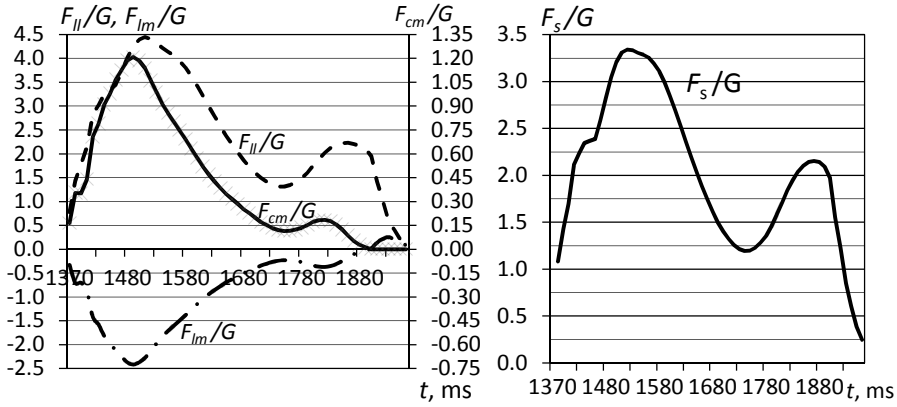

Figure 6: Stair descent – normalized forces in the medial and lateral compartments of the joint, normalised collateral ligament load and normalised total knee load as a function of duration of foot-plate contact

3. CONCLUSION

A method which allows a rapid estimation of the distribution of load in the knee joint has been presented. The benefits of the proposed method are the simplicity of use and rapidly obtainable results, which makes it suitable for ergonomic practice.
The method has been applied for knee joint load analysis during flat surface walking and stair descent. One female subject participated in the research. The calculated knee joint loads during walking on a flat surface achieved a maximum value of 2.5 times body weight. Taking into account walking on a flat surface and stair descent, the curves for knee joint load show a change in shape and amplitude. The maximum value of knee load during stair descent is 3.4 times body weight. In the case of walking with symmetrically distributed weight in both hands, the curves for vertical ground reaction force change in amplitude [6], and the next study should involve an estimation of the load in the knee joint during walking with weight in both hands.

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ERGONOMICS AND PREVENTIVE MEDICINE IN COMPANIES IN SLOVAK REPUBLIC AND THE EU

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Abstract

The authors present the current state of ergonomics in companies in Slovakia in the context of EU legislation. They point to the lack of evaluation of the impact of work and lack of ergonomics programs in Slovakia. The article also compares European and American model approach to ergonomics work. The authors highlight the importance of primary, secondary and tertiary prevention as an essential tool to eliminate musculoskeletal disorder (MSDs) at work. The findings are supported by the results of research on the incidence of MSDs and work-related diseases.

Keywords*: ergonomics, prevention, ergonomic programs, effects of work factors, risks*

1. INTRODUCTION

The aim of ergonomics is health care, specifically physical, mental and social well-being of man, the creation of conditions for optimal human activity, as well as creates a sense of comfort in the workplace. The use of ergonomic principles in practice contributes to creating well-being, the humanization of work and at the same time it also brings economic effect. In addition to these factors, the use of ergonomic principles has a positive impact on economic indicators. These are directly affected by reducing the cost for absence of work, accident, increasing performance and hence productivity growth. This is confirmed by the official definition of ergonomics formulated IEA in San Diego (2000).

2. ERGONOMICS AND PREVENTIVE MEDICINE IN SLOVAK ENTERPRISES

In the period after 1989 in ergonomics and preventive medicine made some mistakes in Slovakia. The biggest mistake was the abolition of doctors working under the guise

of free choice of doctor in companies in Slovakia. This change has many problems passed on specialists of safety and health management who were not and are not professionally trained for it. Currently, some companies are starting to set up in-house clinic. [1]

Another mistake is that ergonomics is disappearing from legislative materials. Policy decisions create a great amount of revisions that complicate the situation to ensure the prevention of work-related illnesses. [1, 2]

A major drawback of the European legislation is that there is no emphasis on the fact that the work and working conditions must not damage the health of the employee. For example, in the U.S. this is true, that if the employee confirms the injury or occupational disease under the Disability Act, company must adequately compensate the employee. The company must then learn what harm his health. Shall rectify the negative factors and to create conditions so that the employee can return to their workplace and the collective to which he was accustomed. [1, 3]

Based on research conducted by the anthropologist prof. Hatiar with his team has been partially mapped and compared the incidence of Musculoskeletal System (MSD) and their intensity in selected EU countries and Slovakia. It turned out that there is no significant difference by employees without difficulty MSD between Slovakia and European samples of employees. Samples are statistically significantly different in the incidence of milder difficulties MSD. Most employees in the sample of European companies have a doctor if they feel easy difficulty localized in MSD. Conversely employees of Slovakia samples courage to see a doctor only when the intensity reaches a degree of difficulty that do not take counter medicines painkillers. [2]

The reason is that in Slovakia, we focus primarily on the protection of business, businessmen and employers who are willing to accept only valid legislation and exploit high unemployment in Slovakia. A system of rewards motivates employees to the less visited a doctor. Employee released because it is not enough to meet the performance standards, the reason is not that got ill at work. Demanding performance standards meet the health employees after job training. Health problems but do not allow it. Ill employee gets into so called social networks.

This situation is consequence of that the company not focus on preventive ergonomic programs. Businessmen focus on profits and are willing to accept ergonomics programs only after verifying that they really bring profit. [6]

3. IMPACT OF WORK AND WORKING CONDITIONS FOR HEALTH EMPLOYEES

Impact of factors of work and working conditions for man at work is often underestimated. It is often claimed that the pains can make people feel at work not only because of the impact factors of work and working conditions, but also for other reasons. [1]

Table 1: Evidence of a causal relationship between factors of physical work and diseases MSD (Source Hatiar, 2012)

BODY PART (syndrome) *Risk factor*	Strong evidences	**Evidences**	**Insufficient evidences**	**Evidences of inaction**
Neck				
REPETITION		√		
Power		√		
Location	√			
VIBRATION			√	
Shoulder girdle				
REPETITION		√		
Power			√	
Location		√		
VIBRATION			√	
Elbow				
REPETITION			√	
Power		√		
Location			√	
COMBINATION OF FACTORS	√			
Wrist and hand				
Carpal tunnel syndrome				
Repetition		√		
Power		√		
Location			√	
Vibration		√		
Combination of factors	√			
Tendovaginitis				
Repetition		√		
Power		√		
Location		√		
Combination of factors	√			
Hand-arm ***vibration syndrome***				
Vibration	√			
Lumbosacral region of the spine				
Lifting and sudden movements	√			
Unsuitable working position		√		
Heavy physical work		√		
Whole body vibration	√			
Static working position			√	

Table 1 shows the results of an epidemiological assessment of 25 years of research carried out at the workplace, which focused on the incidence of difficulties and work-related diseases that have a negative impact on the efficiency and quality of labor. It would be good if those facts applied in European legislation in the field of ergonomics, safety and health at work. [1, 5]

Strong evidences. The evidences are strong when considered on the basis of epidemiological criteria of causality appears to be a causal relationship between intense or prolonged exposure to a specific risk factor or factors and disease MSS as very likely. The positive relationship between exposure to a specific risk factor and disease MSS there could be observed at least in some studies where randomness, bias and confounders factors could be excluded with reasonable certainty

Evidences. The evidence can be said, when some favorable epidemiological evidences show a causal relationship between intense or prolonged exposure to a specific risk factor or factors and disease MSS. There was observed a positive relationship between exposure to a specific risk factor and disease MSS in studies in which, randomness, bias and confounding factors are not a likely explanation. [1, 2]

Insufficient evidences. The evidences are called insufficient, when there are too little available, not consistent and statistically significant studies not in sufficient quality that would allow conclusions on the presence or absence of causal relationships. Some studies suggest a relationship to specific risk factors, which may be explained by randomness, bias or confounding factors (confounders).

Evidences of inaction. We can talk about the evidences of inaction when the studies consistently show that a specific risk factor (or factors) in the workplace is not related to the occurrence of disease MSS. [1, 2]

The risk of work-related diseases can be reduced, respectively, eliminated only when the all aspects of primary, secondary and tertiary prevention are consistently and systematically applied in the practice. Suitable ergonomic intervention of against risk factors is considered to be effective in the prevention of these diseases. [1, 3]

Primary prevention characterize risks to health of workers through technical measures ensures their elimination. Tertiary prevention ensures eliminating of the risk of further damage to the body after adequate rehabilitation, job modification and interference in the work process. This creates the opportunity for the employee's return to work and do the same team, which was accustomed to. Primary prevention measures create conditions for preventing microtrauma, injuries and other disabilities, particularly musculoskeletal system. Secondary prevention measures eliminate risks outside their own working process during the absence of work of man. Tertiary prevention measures to restore the function of the affected workload and congestion and recovered the man

as a worker. Means of primary and tertiary prevention have the same goal. Ensuring the health of the individual in the work process in terms of complexity it is necessary to talk about the secondary prevention that is essential, not least because the methodology and techniques of tertiary prevention are linked to an organic phase of secondary prevention. Primary prevention characterizes risks to health of workers and through technical measures and ensures for their elimination.

4. CONCLUSION

Slovak Republic has processed legislation that is harmonized with the EU legislation. This legislation provides the basis for designing department in companies and solution of machinery and equipment. There are not enough provisions for the application of systematic approaches. The guidelines ensure efficiency of human labor through ergonomics programs for long term maintenance of ergonomics, safety and health of employees. Our research is focused on the production practices that systematically aid in the creation of new ergonomic work systems. We place emphasis on ensuring employee health and increase productivity for companies. Maintaining good human health, increasing humanization of work and labor productivity can only be achieved with complex solutions in the field of ergonomics. [6]

ACKNOWLEDGEMENTS

This work was supported by the VEGA agency of Ministry of Education, Science, Research and Sport of the Slovak Republic contract No. 1/0701/12.

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APPLICATION OF STEREOSCOPIC RECORDS IN ERGONOMICS

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Abstract

The authors are describing the application of stereoscopic records in the industrial engineering discipline. The main focus is to identify the potential for stereoscopic recordings in the field of industrial engineering. Specifically, this focus is in the evaluation process operator workload with the ergonomic analysis. In the first part of the article, the authors are describing the basic process in making stereoscopic records. In the second part, the authors are describing the results of the application of stereoscopic video in the evaluation of operator workload. Stereoscopic video was used as the main source of information in the preparation of analyzes. The result of the survey was the description of the potential benefits of stereoscopic video in industrial ergonomics.

Keywords*:* *ergonomics, stereoscope, productivity, RULA, REBA*

1. INTRODUCTION

This article is summarizing the parts of the results for the research: „Creating of stereoscopic records in industrial engineering“. It was realized by the Department of Industrial Engineering, Mechanical Faculty, University of Žilina. The research is devoted to a comprehensive analysis of the possibilities and potential of creating stereoscopic records in the industrial engineering discipline. This article describes one of the identified applications, which is ergonomics. The article describes specifically the process of evaluation of work by ergonomic analysis. Article briefly describes the process of stereoscopic records and approaches identified advantages and disadvantages of its application in industrial practice, which is evaluated in the end of the article.

2. PRACTICAL APPLICATIONS OF STEREOSCOPY IN THE ERGONOMICS

Verify the practical applicability of stereoscopy as a support tool in the development of ergonomic analysis was carried out in collaboration with SES o.z. (Slovak Ergonomic Association). Videos were created in areas of ZIMS (Zilina Intelligent Manufacturing System), which is a common workplace of CEIT, a.s. and University of Žilina. It is established to support the creation of innovative solutions. For the purpose of experimental verification was created scenario manual assembly coupling fork. Figurant after a short training period carried out the installation of the coupling fork. This assembly was recorded using an own developed stereoscopic camera system (Figure 1).

Figure 1: Stereoscopic camera system (source: authors)

From the generated stereoscopic video, 12 ergonomic analyses were processed next [1]. The following methods were used for the analysis of physical activity in cyclical repetition of activities:

- RULA
- REBA
- STRAIN INDEX
- CTD RISK INDEX

Figure 2: Preview of stereoscopic record (source: authors)

Evaluation of parameters for the working process through ergonomic analyzes were processed in order to confirm of refute the possible benefits of stereoscopic imaging in

the process of ergonomic analysis. Display preview by stereoscopic screen is shown in figure (Figure 2).

2.1. Procedure for creating a stereoscopic recording

Creating of stereoscopic recording in industrial conditions should be conducted in the following four steps (Figure 3):

1. **Choosing the appropriate position for the creation of stereoscopic recording.**
   By selecting a suitable position for the camera, is the most important criteria a recorded space, given the need for a detailed analysis of the workplace. It needs to be recorded complete work operations under consideration, with all its elements. It is also necessary that the record clearly visible all the operations staff with a direct view of the hand movements.

2. **Settings the parameters of the camera system.**
   Setting options of developed camera system is described in detail in the research work. Some aspects of the procedures have been previously published [2], [5], [6]. In case of a commercially of this available camera system is necessary to follow the instructions for use.

3. **Creating a record.**
   If a record is creating, is important that there has been at least one complete cycle of analyzed operations. To better assess compliance workflow workers is appropriate if these cycles is recorded more.

4. **Processing and editing the record.**
   Treatment process consists in cutting the recorded results. It is necessary to record the whole process, from beginning to end. In this step is also performed stereoscopic video synchronization.

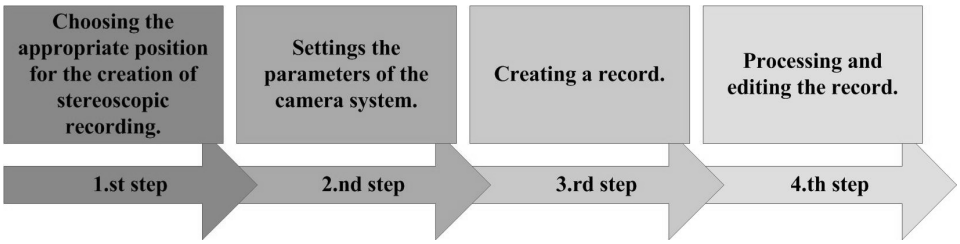

Figure 3: Procedure for creating a stereoscopic record (source: authors)

2.2. Disadvantages of stereoscopic applications in ergonomics

Creating of stereoscopic record requires, at first sight, a large time commitment. It is true, that the creation of stereoscopic video is more time consuming than creating a classic movie. However, the time differences are small. The average time duration of each step of stereoscopic (Table 1) is determined based on the author´s experience of research.

The need of time for creating a 3D record is comparing to creating 2D record 20 % higher. It is only 7 minutes, in minute terms however. These seven minutes arises in two steps.

Table 1: Comparison of classical labor content and stereoscopic video (source: authors)

Steps in the process of stereoscopic	The need of time for steps	
	Creating 2D record	Creating 3D record
Choosing the appropriate position for the camera	3 min	3 min
Setting the parameters of the camera system	0 min	2 min
Creating a record	15 min	15 min
Processing and editing record	15 min	20 min
∑	33 min	40 min
∑	100 %	120 %

The first step, with a higher time demands, the parameter settings a camera system that records exercised in 2D. With the use of a help calculation file, this step takes an average of only two minutes. These two minutes are also the only extension of the time spent for recording work. Total time spent at work is a very important factor with regard to minimizing disruption of normal work activity operators.

The second step, with more time-intensive, is processing and cutting the movie. In this step a video clip is processed and edited so that the analyzed operation recorded in its entirety. This step also performs synchronization of the two images. The first record is completely analyzed and the selected time passages which record the project as a whole, the second entry is already selected by only times edited. By using specialized software for processing stereoscopic video this time difference is even smaller.

2.3. Benefits of stereoscopic applications in ergonomics

A slight increase in time consumption is offset by the creation of ergonomic analysis of the recorded work. Time compensation is generated by improving the ergonomic analysis of work in spatial vision analyzed workplace. Direct spatial vision of the workplace allows an increase in productivity of work in the assessment of workplace ergonomic parameters in the following activities:

1. **Analysis of potential risk activities and movements.**
   When is analyzing the work, the ergonomist doesn´t create an analysis on all movements and operations of operator in the workplace. That would in fact be very time consuming and inefficient. Ergonomist based on his knowledge and experience needed to quickly identify potentially risk activities and movements, which subsequently analyzed in detail. Spatial vision of the operation eliminates the need for ergonomics and spatial imagination allows

him to quickly and efficiently identify potentially risk movements and activities.

2. **Detailed analysis of selected activities and movements.**
   After selecting of potentially risk movements and activities, it followed by their detailed analysis. Detailed analysis of each activity requires information about the spatial orientation of the worker during the analyzed situations. Spatial reproduction of the record of the activities of an appropriate support tool that provides ergonomics information necessary for fast and high – quality construction of the necessary analyzes.

2.4. Evaluation

Practical design analysis support for stereoscopic video confirmed the potential of stereoscopic imaging as an advanced instrument for industrial engineer. The third dimension of the display device has brought a better orientation in the spatial arrangement of the workplace. [3], [4], [7] If we are creating ergonomic analyzes in support of classic movies are the biggest requirements for spatial imagination of the observer video. Spatial reproduction movie establishes an observer semblance direct presence in the workplace and real observation worker. It eliminates the need for spatial imagination of the observer, and creates more scope for direct focus on specialist factual analysis considered the workplace. Stereoscopic videos creates a support for improving ergonomics following activities:

- creating a load analysis,
- creating a time and motion analysis,
- identification of ergonomic problems in the workplace,
- analysis of compliance workflow.

The need to reduce consumption of time required to analyze the current state can be regarded as a very frequent practice requirement. By fast analyzing is important to keep a detail, precision and quality of the analysis of the current state. The need to improve the speed and precision are simultaneously achieve two requirements when creating analyzes. And that 3D imaging device generates the necessary support for fast creation of analysis while promoting quality and precision.

3. CONCLUSION

In conclusion the surround recording and reproduction brings the necessary value added in the process of ergonomic analyzes generated by the movie. Adding a third dimension to an observer compensates the greatest shortage of classic movies, which is poor spatial orientation.

ACKNOWLEDGEMENTS

This work was supported by the VEGA agency of Ministry of Education, Science, Research and Sport of the Slovak Republic contract No. 1/0701/12.

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APPLICATION OF TACHOGRAPHS IN ROAD TRANSPORT

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Abstract

The purpose of this paper is to emphasize the tachograph as an irreplaceable instrument for tracking the operations of the driver in commercial, cargo and passenger road transport. The main point of this research is to explain the implications of the tachograph as an instrument which tracks work load of professional drivers and at the same time eases the tracking of the drivers driving technique and also has high potential in prevention of road accidents.

Keywords: *tachograph, road transport safety, duration of vehicle operation*

1. INTRODUCTION

The application of tachographs in road motor vehicles has multiple positive implications. The tachograph allows tracking of the driver in relation to several different criteria: duration of vehicle operation, distance, speed, value and frequency of slowing down and speeding up and resting time. It is a fact that continuous operation of a motor vehicle without rest causes the driver to tire and lose concentration which could result in severe consequences for everyone in the traffic system. The duration of vehicle operation until traffic conflict has been researched by Rajsman on the example of the bus driver, which showed that the sixth hour was critical in showing a greater amount of traffic accidents in which the fault lies in the driver. [1] Jelčić, Milošević, Raffle, Šeparović and other recognized domestic and foreign experts and scientists have also contributed to the connection between fatigue and its influence on the drivers capabilities in their research papers. [2, 3, 4, 5, 6] Kroemer and Grandjean cite the following scientifically determined facts: the alertness and attention of cargo drivers begins to significantly fall after 4 hours of continuous driving so the risk of accidents increases, in bus drivers, first signs of reduced efficiency occur after 4 hours of continuous driving, which becomes dramatic after 7 or 8 hours of continuous driving. [7]

2. TACHOGRAPH

A tachograph is an instrument that primarily record speed and distance. The term tachograph also implies a surveillance instrument which also tracks time spent in performing professional activities which are not driving, like rest. There are two types of tachgraphs:

- **analog tachograph**, the information of work activities, speed and distance is recorded onto so called tachopapers - patterns of circular shape which the driver inserts into the tachograps (picture 1);
- **digital tahograph**, stores information onto digital smart cards, the driver can buy his own digital identification card which he can use in driving.

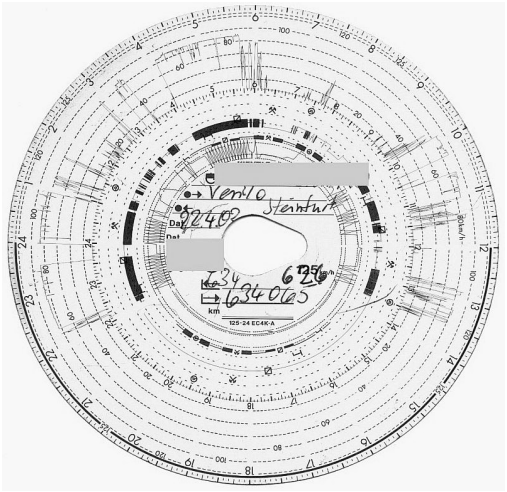

Figure 1: Tachograph paper - analog tachograph [8]

Source: http://hr.wikipedia.org/wiki/Tahograf

Since the year 2009 in Croatia, there is an obligation to install tachographs into all newly registered vehicles. In Croatian transporters the percentage od analog tachographs is still very high.

3. WORK HOURS AND MANDATORY REST PERIODS FOR PROFESSIONAL DRIVERS AND ROAD TRAFFIC

The Law on work hours, mandatory rest periods of mobile workers and tracking instruments in road traffic states basic rules for tachograph use in recording the drivers activities. The Law permits the use of analog and digital tachographs. Digital tachograph is mandatory for all members of the European Union which has also been undertaken by Croatia which has signed the agreement on work of the crew aboard vehicles that conduct international road transport. Article 2 of the above stated Law determines which transporters must have digital tachographs. All new vehicle with the mass above 3,5 tons and busses that carry more than 9 passengers starting from January

1st 2009 must have a digital tachograph. Croatia is a first non-member of EU that has introduced digital tachographs. The biggest news in the work hours surveillance system of mobile workers is the introduction of personalized memory card as a substitute for the analog tachograph papers. The driver also receives three other cards: transporter card, supervisor card and workshop card. Every professional driver has a personalized card that contains all relevant data: work hours, distance, rest periods. The data is also recorded in the memory of the tachograph in the period of one year. [9, 10]

The proscribed limitation in duration of vehicle operation and the shortest rest period of the driver of the cargo vehicle above 3,5 tons and busses is given in the table below (table 1). The table also contain limitations according to Croatian, EU and AETR standards.

Table 1 The proscribed limitation in duration of vehicle operation and the shortest rest period of the driver

	CRO (hours)	EU	AETR
Drive duration			
Continuous daily	4,5h 9h 10h two times/week	4,5h 9h 10h two times/week	4,5h 9h 10h two times/week
weekly	56h	56h	-
two weeks	90h	90h	90h
Drive interruption			
After drive duration	4,5h	4,5h	4,5h
min. duration	45 min.	45 min.	45 min.
frequency of interruption	15 min. max. 2 times in 4,5h of drive (15+30 min.)	15 min. max. 2 times in 4,5h of drive (15+30 min.)	15 min. max. 3 times in 4,5h of drive
Daily rest	Regular: 11 h continuous in 24 h	Regular: 11 h continuous in 24 h	Regular: 11 h continuous in 24 h
1 driver	12 h in 24 h in two parts, first 3 h continuous and second 9 h continuous	12 h in 24 h in two parts, first 3 h continuous and second 9 h continuous	12 h in 24 h in two parts, first 3 h continuous and second 9 h continuous
2 or more drivers	9h continuous every 30 h	9h continuous every 30 h	9h continuous every 30 h

In passenger transport the driver must not drive longer than 9 hours with the rest periods of 45 minutes, and if there are two drivers than they must not drive longer than 20 hurs without mandatory rest of 45 minutes of each driver. In cargo transport, daily rest period is at least 11 hours of continuous rest that can be split into two parts of which the first can be 3 hours long and the second 9 hours long. When there are two drivers, the only

difference is that every 30 hours the drivers must have continuous rest of at least 9 hours.
[9, 10]

4. CONCLUSION

The tracking of work hours of professional drivers in road passenger and cargo transport is very important above all for the safety of all traffic participants. The application of tachographs is mandatory according to regulations which allow tracking of work hours of commercial motor vehicle crew, analysis of work load of each individual driver and application of rational driving techniques. The contribution of tachographs is not solely tracking the work hours of the driver, obeying the regulations in terms of work hours, mandatory rest periods but also the possibility of prevention of road traffic accidents.

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PROTECTIVE MEASURES AGAINST TUNNEL FIRE

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Abstract

Special fire risks are tunnels of great lengths where interventions are difficult. Several disastrous fires in tunnels in the last few years (Mount Blanc, Tauern, Gothard) dramatically warned that tunnels are extremely dangerous places on roads. A traffic accident on a road does not need to have casualties, but in a tunnel, especially when accompanied by fire, can turn into a tragedy. Therefore, in the tunnels particularly stringent fire protection measures must be applied.

Keywords: *tunnels, fire danger, fire protection*

1. INTRODUCTION

Today there is a huge traffic of cars, trucks, trailers, tankers and other vehicles moving on public roads, viaducts, bridges, tunnels and the like. In such a traffic various hazardous substances are transported, and unadjusted speeds, defects or non-compliance of traffic safety rules can cause great accidents [7]. In such cases, fire or explosions, spills of hazardous liquids, water or soi pollution and the like can occur. A tunnel is an underground passageway, completely enclosed except for openings for entrance and exit, commonly at each end. It is used for the transportation or hydraulic purposes (Figure 1).

Figure 1. The old tunnel (Motovun)

from the point of view of fire the attention is paid to tunnels for road and rail traffic.In history the first indications of tunnels are found in the tombs of the Egyptians 2000 years before Christ and Namibian caves. In Jerusalem 1000 BC a 537 m long tunnel for water was built. A 1000 m long tunnel on the island of Samos in the 7th century BC is also known. Nebuchadnezzar II of Babylon, a Chaldean, dug beneath the Euphrates River a 4.6 m wide and 900 m long passagel, and the first 1000 m long road tunnel was built in Naples 36 years BC. In addition to the already existing tunnels on the A1 motorway Zagreb-Split-Dubrovnik (20 tunnels) the total length of 23,774 m, A2

Zagreb-Macelj (6) 3511 m, A4 Zagreb-Goričan (2) 1151 m, A6 Bosiljevo River (12) 10011 m , A7 Rupa-Rijeka (3) 896 m, A8 Kanfanar-Pazin Matulji (3) 5262 m, Rijeka bypass (5) 2354 m, as the total length of 36,948 m, Croatia became a tunnel superpower alongside the famous Alpine tunnels.

2. TUNNEL EQUIPMENT

To better clarify which fire protection measures in a longer tunnel are necessary, one should start from the technical characteristics essential for each building, which apply to safety in case of fire [4]. Therefore, buildings must be designed and constructed so that in case of fire: load capacity is preserved over time, spread of fire and smoke in the building is prevented, spread of fire to adjacent buildings is prevented, people can leave the building unharmed, or their rescue is made possible and and the protection of rescuers [5]. Modern tunnels primarily on highways are generally equipped with sophisticated equipment that ensures the highest level of safety when driving and going through the tunnel. Tunnel equipment is determined by the category of vulnerability, which is defined in the Regulations on the classification of buildings and building parts and spaces in fire risk category.

2.1. Signaling

The tunnels are equipped with signs and road signs, constant and variable managed from the control centers (Figures 2, 3 and 4). Evacuation line on the tunnel lining is drawn over the entire length of the tunnel on the side where there are the entrances for pedestrians and passages for vehicles with a red 50 cm wide line (Figure 5).

Figure 2. Tunnel traffic sign

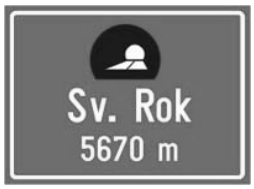

Figure 3. Road construction sign

Figure 4. Fire exit sign

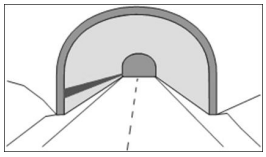

Figure 5. Evacuation line

2.2. Ventilation

Apparatuses for ventilation and infiltration of fresh air provide normal conditions of traffic. The design of the ventilation system must take into account three objectives:

- Dilution of pollutants inside the tunnel

- Protection of the environment at the exit of the tunnel
- Control of fire and smoke.

The amount of fresh air which must be fed into the tunnel must dilute exhaust gases so that toxic concentrations of CO are reduced to the limit and to dilute the smoke of diesel engines and thus achieve the prescribed visibility in the tunnel of a few hundred meters. The required amount of fresh air for the dilution of the diesel engine smoke is much greater than the amount of fresh air necessary for the exhaust gases of gasoline engines, and in some countries where there are no restrictions for the concentration of NO_2 the amount of fresh air is even higher. Types of ventilation systems:

- Natural ventilation is the result of meteorological activity, and piston action of the vehicle.
- Longitudinal ventilation uses jet fans or sometimes air injectors to create a uniform flow of air along the tunnel (Figure 6. a Figure 7.).

Figure 6. Longitudinal ventilation

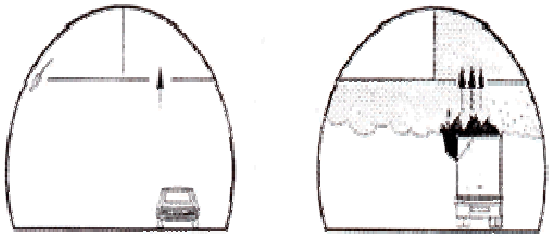

Figure 7. Transverse ventilation

In semi transverse ventilation there is only one channel through which the normal operation feeds fresh air, and in case of fire he becomes sluice for smoke from the tunnel. In order to control the spread of fire and smoke tunnels are divided into the ventilation sections by making one or more vertical shafts or exhaust gas channels.

2.3 Lighting

Entry and exit lighting of tunnels is most intense at the entrance to the tunnel pipe, and gradually decreases to the specified level in the tunnel, and gradually increases to the exit of the tunnel where it is the most intense (Figure 8.). In this way, it helps the adaptation of the eyes in the dark when entering the tunnel and the light at the exit of the tunnel. Along the entire length of the tunnel security lighting (especially with emergency and security cabins) is installed. Twin-tube tunnels are interconnected tubes that serve as passageways for possible evacuation, and are secured with fire and smoke protection doors (Figure 9).

Figure 8. Lighting in the tunnel

Figure 9. Evacuation routes

2.4. *Video surveillance*

The tunnels are equipped with video surveillance of traffic to detect potential failures and their place in the tunnel by monitoring the driving speed through the tunnel, and devices for the timely detection and alarm about the spread of fire in tunnels.

2.5. Fire Alarm System

It must register a fire as soon as possible, must be reliable and resistant to false alarms, and possibly provide other information that may be of help to firefighters and rescue services in the tunnel. The basic elements of a tunnel fire detection system does not differ significantly from the system in a different facility. Elements of the system include: fire alarm control panel, manual fire alarm systems, automatic fire alarm systems, elements of the system to forward the fire signal, elements of the management ***a fire extinguishing system – supply.***

2.6. Communication System

In tunnels with a control center it must be possible to switch the radio broadcast channel for the users of the tunnel in order to transmit emergency messages. Evacuation routes and other places in the tunnel where the tunnel users are waiting for evacuation in an open space are equipped with loudspeakers for providing information.

2.7. Hydrant network

For all tunnels a sufficient supply of water through a fire hydrant or in any other appropriate manner must be ensured [3]. Hydrants shall be placed near the portals on the outside and inside of the tunnel, at a distance that in new tunnel should not be greater than 150m, and in existing tunnels no greater than 250m. The capacity of the hydrant system must allow taking water at a rate of 1200 l/min. for a period of one hour. If it is not possible to connect to the local water supply, vertical tanks with a capacity of 80 m^3 should be installed. The equipment that is installed with the hydrants in the tunnel must allow extinguishing Class A and B fires with at least two hydrants [9].
In addition to the above mentioned equipment that is an integral part of every tunnel, the tunnel must have a control center and a fire brigade.

3. BASIC CHARACTERISTICS OF TUNNEL FIRE

Fire is defined as uncontrolled burning which may lead to personal injury, property damage, and environmental impact. Burning can produce combustion products, such as heat, flame, smoke, soot, fumes, sparks, ash, embers, coals etc. All these combustion products have different hazardous properties that may affect the environment. Fire itself can also indirectly be the cause of new environmental accidents. Hazardous substances most commonly occurring after a fire and explosion are combustion products as: carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO, NO_2), sulfur gases (H_2S, SO_2), hydrogen chloride (HCl), hydrogen fluoride (HF), hydrogen bromide (HBr). These harmful substances result from burning plastics and similar materials.

3.1. Fire fighting

Fires in tunnels require special tactics of fire fighting because a number of specific phenomena, risks and contingencies emerge. In these fires people are often killed, which requires combined action, i.e. the active localization and rescue personnel. In these actions firefighters face obstacles, surprises, potential risks, especially in terms of heat that does not permit and denies access to the fire site, specifically to burning cars. Firefighters are exposed not only to gaseous and aggressive products of combustion, but also to the risks of the consequences of thermal effects on the building, the damage of tunnel equipment, covering damage, as well as a tunnel collapse [1]. Carcinogenic hazards from a variety of materials, especially those applied to the insulation, are not excluede. Extinguishing such fires is limited, takes place indoors, without free and available communications required by firefighters. Poor visibility or no visibility at all occurs because panic lighting is unreliable and lighting is hardly feasible. With regard to the type and quantity of combustible substances and objects in tunnel fires, we can say that unlike the fire of those substances and objects outdoors, they do not belong to any particular category or classification. Passenger cars, buses, trucks or railroad cars and other means of transportation and operation, have the same physical and chemical properties, regardless of whether there is a fire outdoors or in a tunnel. Differences may be in the behavior of certain substances in the reaction conditions with sufficient or insufficient oxygen saturation and air, and action of high temperatures. There is fuel, rubber, sponges, paints, varnishes, synthetic materials and objects in all the vehicles. When fire is set on these substances and objects in a room or area such as a tunnel, where there are conditions for the stoichiometric ratio of burning, and there is no place for alleviation, removal or interference with the environment of greater volume, resulting products are exothermic chemical process, which leads to the formation of critical temperatures for the fire. Unlike the fire of such substances and objects outdoors, where the maximum temperature achieved in the third stage of fire spreading to the fourth phase decreases, the fire in the tunnel does not happen, but the temperature curve of fire III and IV stages of development is the same. This is the reason why the consequences of such a fire are catastrophic

Let us add that the fire temperature curve, after a maximum temperature was achieved in a fire outdoors, falls after the substance burnt down, because there is no burning substance in the center and at the boundary points of the fire or fire limits the heat is significantly reduced because of the reduction in the effect of localization by release into free space, the immediate removal, etc. It is clear that it does not happen where there is a burning substance in sufficient amounts or is so arranged that the temperature

curve can expand forever and when there is no impact on the process. Such exothermic chemical reaction, called burning transfers in chained spread of fire which has disastrous consequences. It may happen in tunnels that after burning combustible substances, the maximum temperature increases, i.e. fire curve in relation to the resulting heat does not decrease due to the listed specifics, so this situation greatly aggravates the intervention of fire-fighters, just in the first most important minutes of intervention. The situation at the fire site becomes dramatic because firefighters are powerless or upon arrival at the fire site they cannot reach the center of the fire site, to the injured, which assumes other characteristics as well.

3.2. Tactical performance

In the process of fire fighting in the tunnel there is no established and accepted rule of tactical performance [1]. Without a doubt, a decision for the combined performance with an emphasis on the potential dangers should be made. The action is not undertaken with a small number of human forces because they quickly get exhausted as they have to apply protective equipment such as respiratory equipment and protection against heat. Respecting the rules of the rescue, it is necessary to focus solely on the action of pulling the injured from the fire, and to call medical assistance teams, and they must sbe in the vicinity of fire fighters. The type of tactical performance is determined by etermines location of fire in the tunnel. There can not be any mistake because the only viable frontal appearance, if it is possible to get to the very focus that is burning or burning vehicles. Exceptions are in subways or tunnels where there are available ways to more places, and depending on the situation and possible intervention.With regard to the localization of the fire site active localization is obligatory if it is possible to perform it. In most cases passive localization is used because of the resulting situation.

4. CONCLUSION

Despite all the architectural, technical and organizational preparations saving human lives in the tunnel systems often exceeds the possibilities of firefighters, and therefore great attention must be paid to rescue options. With proper signaling, safe escape routes, effective systems for smoke evacuation and automatic devices for fire extinguishing, with which fire speed can be slowed down or even prevented and the reduction of temperature provided to a sustainable level, the education and behavior of traffic participants play a decisive role.

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APPLICATION ERGONOMIC PRINCIPLES IN THE WORK ENVIRONMENT FAMILY HOME

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Abstract: This paper presents the results of research ergonomic factors that affect the working environment in the family home, which provides services for the elderly and employing workers in different occupations. They questioned the conditions of life and work related to the micro-climatic conditions (air temperature, air velocity, and relative humidity), light and noise.

Keywords: family home, microclimate, lighting, noise

1. INTRODUCTION

Environmental conditions can damage the health and life-threatening. Proper assessment of the impact of the process on health is a prerequisite for appropriate preventive activities and health at work in different economic sectors, certain professions and specific work processes. Particular attention is paid to the protection of mental health at work. The efforts of the adjustment of self-preservation, there is stress, one of the biggest health problems in the workplace mjestu.Ispitivanje ergonomic factors of the work environment includes examining physical (temperature, humidity and air velocity, light, noise and vibration) and chemical factors (concentration of gases, vapors and dust). Examination of these parameters is very important issue in the implementation of work because all aspects of the work environment have a great impact on people. The employer is required to perform the tests in the work environment:

- In work areas where the performing process affects the temperature, humidity and air velocity,
- In work areas and work areas outside the work premises where the work process is resulting with noise and vibration,
- In which the work is necessary to provide adequate lighting.

The purpose of the study of individual parameters of the work environment is to determine are the results within the limits specified by the regulations and standards relating to specific areas. A healthy work environment is one of the most important prerequisites for human health and satisfaction in the workplace. For this reason it is

necessary to regularly perform testing of the working environment and to take all steps to ensure that test results were within the limits specified by the regulations and standards in accordance with workplace.

2. RESEARCH ISSUES

The purpose of the study of individual parameters of the work environment is to determine how test results are within the limits specified by the regulations and standards relating to specific areas. The working environment is regulated by a series of regulations, whether the results are within the limits specified by the regulations and standards, and whether they supervise tests of this kind. The Republic of Croatia has not yet developed an awareness of the importance of health and safety at work. Most companies do not test work environment, although these tests and their control is law determined. Conditions in the work environment greatly affects the health and safety of people. In Croatia there is still a common practice of displaying incorrect results analysis only to meet the legal formality and that the paper was fine. The issue of research is that we do not have a sufficient number of accurate information about what is truly state of the practice, nor that attaches importance.

3. RESEARCH GOAL

The aim of the research is to determine the real situation in practice, and to take all necessary measures to improve working conditions. The test was performed in all areas of home, rooms, kitchens and living rooms. Working environment testing was carried out in accordance with Article 50 Law on Occupational Safety (Official Gazette no. 59/96, 94/96, 114/03), the Ordinance on the working environment, machinery and equipment with high risk, and the content, form and manner of issuing documents (OG. 52/84 , 114/02 and 126/03) and the Ordinance on occupational Safety and Health for operating rooms and spaces (OG. 6/84.), and applicable standards, based on the decision of the Ministry of Economy, Labour and Entrepreneurship.

4. HYPOTHESIS

Based on research, the working environment in the family home we hypothesize that the actual situation is satisfactory, or that all parameters are within the boundaries of the standards and regulations for a particular area.

5. EXAMINATION OF ERGONOMIC FACTORS IN WORKING ENVIRONMENT

The working environment in the family home was conducted in accordance with Art. 50 of the Occupational safety on which is composed record.
Testing was performed on the circumstances:

- microclimate (air temperature, air velocity, relative humidity)
- lighting
- noise

Table 1: Display of specific data for microclimate

Microclimate factors:	(air temperature, air velocity, relative humidity) Air temperature, relative humidity and air velocity testing is performed where workers spend most of their work time, where is determined: ▪ Whether by the action of heat and heat transfer due to the environment in refrigeration, air temperature meets the microclimate conditions for thermal comfort at work ▪ Whether due process of heat or refrigeration relative humidity and air velocity satisfy microclimate conditions for thermal comfort at work. Under the work area shall be any outdoor or indoor space in which people work. Depending on the type of job measurement can be performed in one or more places, as well as the characteristic places in the room. Optimum operating temperature (for PSI = 0) shall be determined on the basis of data on the CLO values and apparel workers, and information about MET values and physical activity of workers.
Instruments	METREL, Multinorm MI 6201, serial no. 09500030

Table 2: Illumination

Illumination	Purpose of illumination testing is to determine the strength of illumination and whether it meets the Croatian standards with regard to certain types of jobs. Illumination testing is done in the most unfavorable light conditions when all means of work are operational.
Instruments	METREL, Multinorm MI 6201, serial no. 09500030
Display of illumination standards for evaluation:	

Review of these requirements is given in the table of Croatian standard HRN U. C9.100.

To carry out certain activities in general lighting or for general and additional lighting at the workplace, the average brightness of the premises must be permanently in accordance with the requirements of Table 3.

Table 3: Display of average illumination according to HRN UC9.100.

Requirements	Only general illumination	General illumination with additional illumination at the workplace				
		General illumination		Additional illumination at the workplace		
	The minimum average illuminance lux (lx)					
	a	b	A	b	a	B
Very low	30	50	-	-	-	-
Low	50	80	-	-	-	-
Medium	80	150	30	50	150	300
High	150	300	50	80	300	600
Very high	300	600	80	150	600	1000
Extremely high	-	-	150	300	Over 1000	

Note: Value of illumination in column "a" in the table applies for illumination with incandescent bulbs, then values in column "b" for illumination with flourescent tubes or similar sources of illumination higher color temperature.

Table 4.: Noise parameters

Noise	Noise examination is implementing because of noise level determination at places of static and periodical staying when all machines and devices are in use and other sources of noise which are in use at the same time. Under workplace it is considered every open or workplace where people works. Under harmful influence it is considered noise which particularly interferes many types of activites, speech communication, sideline communication with expedient of communication, receiving sonic signals and damaging sense of hearing. Depending on type of workplace measurement can be done on one or more places, as well as on specific places in environment. At the workplace noise is measuring at workers head height when he is not present. If the process demands worker's presence, microphone is setting up on a distance cca 10 cm from worker's ear.
Instrumentarium:	METREL, Multinorm MI 6201, serial no. 09500030
Grading of noise level display:	Grading harmul activity of noise is done on basis warning and boundary values exposing on while 8 hour workday and peak level of values of sonic pressure: a) lower warning border of exposing Daytime level of noise exposing: $L_{EX,8h}$= 80dB(A) and $p_{(peak)}$= 112 Pa (135 dB(C) compared to referent sonic pressure 20μPa). a) upper warning border of exposing: Daytime level of noise exposing: $L_{EX,8h}$=85dB(A) and $P_{(peak)}$= 140 Pa (137 dB(C) compared to referent sonic pressure 20μPa). b) border exposing value Daytime level of noise exposing: $L_{EX,8h}$=87dB(A) i $P_{(peak)}$= 200 Pa (140 dB(C) compared to referent sonic pressure 20μPa). For peak values applies, employer at determining real exposure of worker has to consider lowering noise level because usage of personal protective equipment for hearing protection, while for cautionary exposing values applies that this effect must not consider. But if daytime noise exposure, which workers are exposed, from day to day significantly changes for judgement of noise level can be used in weektime of noise exposure providing the weektime exposure does not exceed peak values of exposure 87 dB(A). It is considered, the work is disturbed by noise, if at work specifically for respective workplace is surpassed equivalent noise level described in Contribution Rule Book of protection of workers from noise exposure at work (NN RH no. 46/08).

6. TEST RESULTS

Table 5.: Results of measuring physical – chemical parameters

Measuring physical – chemical parameters							
Examination place		Family home building					
Date of examination	25.03.2011.	Examination time	12:00	Outdoor temp.	14,6 °C	Relative humidity	48,0 %
Physical and chemical parameter		Workplace					**Application**
		1	2	3	4	5	
		Room 1	Room 2	Room 3	Room 4	Room 5	
Air temperature [°C]		22,2	22,1	22,0	23,2	21,9	$20<t_{zr}<24$
Relative humidity [%]		44,7	44,3	44,1	43,9	42,6	$30<\varphi<70$
Air velocity [m/s]		0,05	0,05	0,05	0,05	0,05	$v<0,5$
Noise [dB(A)]		26	27	26	29	28	$L_{eq}<60$
Illumination instensity E+D[lx]		151	181	193	188	211	$E_m>300$ (150)

General mechanical ventilation						

Workplace - environment	MET*	CLO**
Office	1,2	1,0

Measuring physical – chemical parameters							
Examination place		Family home building					
Date of examination	25.03.2011.	Examination time	12:00	Outdoor temp.	14,6 °C	Relative humidity	48,0 %
Physical and chemical parameter		Workplace					**Application**
		6	7	8	9	10	
		Room 6	Room 7	Room 8	Room 9	Room 10	
Air temperature [°C]		22,0	21,8	22,8	23,6	20,9	$20<t_{zr}<24$
Relative humidity [%]		44,2	43,5	44,1	46,2	44,2	$30<\varphi<70$
Air velocity [m/s]		0,05	0,06	0,05	0,09	0,08	$v<0,5$
Noise [dB(A)]		29	26	27	29	28	$L_{eq}<60$
Illumination intensity E+D[lx]		321	191	254	286	195	$E_m>300$ (150)
General mechanical ventilation							

Workplace - environment	MET*	CLO**
Office	1,2	1,0

Measuring physical – chemical parameters							
Examination place		Family home ROŽIĆ, Pribanjci 48, Bosiljevo					
Date of examination	25.03.2011.	Examination time	12:00	Outdoor temp.	14,6 °C	Relative humidity	48,0 %
Physical and chemical parameter		Workplace					**Application**
		11	12				
		Kitchen	Office				
Air temperature [°C]		22,2	22,9				$20<t_{zr}<24$
Relative humidity [%]		46,0	43,7				$30<\varphi<70$
Air velocity [m/s]		0,11	0,05				$v<0,5$
Noise [dB(A)]		39	37				$L_{eq}<60$
Illumination intensity E+D[lx]		217	300				$E_m>300$ (150)
General mechanical ventilation							

Workplace - environment	MET*	CLO**
Office	1,2	1,0

* Information about MET values and physical activities
** Information about CLO values and worker clothing

7. TEST RESULTS GRADING

Microclimate factors [^{o}C, %, m/s] for transitional period.
Measured microclimate factors **meets** rules of occupational safety.
El. illumination [lx]
Measured intensity of electrical illumination workplaces **meets** required minimum demands to norm HRN U.C9. 100/62 with using additional local lighting.
Noise [dB (A)]
Measured noise level **meets** rules of occupational safety.

8. CONCLUSION

By results of measuring and examinating can be concluded that all microclimate factors (air temperature, relative humidity and air velocity) for winter time, electrical lighting and noise in observed working places are satisfied.
Measured values are in harmony with norm sizes.
Considering that rules of occupational safety are used by regulation article 17. Rule book of way of measuring working environment and machinery and devices with increased risks (NN RH 114/02) for specified rooms and places **can be issued assurance for registrated activity.**

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(NN SRH 6/1984)
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[6] Ordinance on safety and health in the use of work equipment (NN RH 21/08)
[7] Regulations on maximum permissible noise levels in the environment in which people work and live
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[10] HRN U.C9.100, Daily and electric lighting rooms in buildings
[11] HRN EN ISO 7730:2003 Moderate thermal environments

COTTON SOCKS FOR DIABETICS - INVESTIGATION OF SOCK PARAMETERS

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Abstract: *Diabetes has become a major public health problem and grows rapidly in the most developed countries of the world. Beside genetic and environmental factors, lifestyle habits play an important role in the development and progression of diabetes mellitus. About 15% of diabetic patients develop a foot ulcer in need of medical care according to the World Health Organization (WHO). Infection is a serious complication and it is the major responsible cause of lower limb amputation. This paper deals with the possible protection from diabetic foot infection with the socks made of modified cotton yarn by natural minerals and active carbon. Ten diabetic patients - 3 IDDM, 4 NIDDM and 3 GDM, tested in vivo fabric hand according to AATCC EP 5 guidelines and sweating evan after 15 washing cycles to accomplish the highest possible level its comfort of diabetic patients. Additionally, antimicrobial protection was determined by standard methods.*

Key words: *diabetes mellitus, diabetic foot, socks, minerals, active carbon, sweat, fabric hand, antimicrobial protection*

1. INTRODUCTION

Diabetes mellitus and its chronic complications are the major public health problem and grow rapidly in the world. Over 366 million people are currently affected worldwide with diabetes mellitus, mostly in developed and newly industrialized countries [1]. It is well known that beside genetic factors, environmental and lifestyle habits play an important role in the development and progression of diabetes mellitus, especially type 2. Lifestyle and nutrition of diabetic patients are very far from guidelines of the World Health Organization (WHO). On the other hand, body weight and physical activity are critical factors for diabetes prevention in persons with normal and impaired glucose tolerance. They are very important in the regulation of the disease and development of its chronic complications as well [2,3].
There are several types of this disease different by origin, treatment and clinically:
Type 1 – insulin-dependent "juvenile-onset" diabetes (IDDM);
Type 2 – non-insulin dependent diabetes (NIDDM), "adult-onset" diabetes, is characterized by insulin resistance and relative insulin deficiency;
Gestational diabetes mellitus (GDM) is first diagnosed during pregnancy through an oral glucose tolerance test; and other special types. Type 2 diabetes is the most common form of diabetes, affecting about 85% of all people with the disease; only 8% are the people with diabetes type 1. The rest goes to the other types of the disease. Regardless

on type, postulates for diabetes treatment are the same – nutrition, exercise, self-control, per oral hypoglycemic drugs, insulin. Following these five postulates in the most cases diabetes can be well regulated, and the micro and macro vascular complications, that make the main problem to patients and the biggest expense to insurance companies, postponed.

According to the World Health Organization (WHO) about 15% of diabetic patients develop foot ulcers which are the result of neuropathy and ischemia. Neuropathy is characterized with loss sense which has protection function as well. Sense loss enables easier ulcer formation on pressure points of foot. Present sweating disorder contributes to the skin vulnerability as well. Circulation disorder reduces blood flow resulting in necrotic tissue that is a good foundation for infection. Diabetic foot infection is common complication of diabetic patients, responsible for large number of lower limb amputation. From diabetic foot ulcers the coagulase-negative staphylococcus, enterobacteria and aerobe streptococcus are isolated. Enterobacteria have fecal origin; they are Gram negative bacteria that include pathogens such are *Escherichia coli, Proteus spp, Klebsiella spp, Salmonella, Yersinia pestis* etc. Anaerobic microorganisms are more common at severe infections. Micro fungi and viruses are very rare in diabetic foot infection, but they are responsible for unpleasant foot odors [4].

Textiles are an excellent substrate for bacterial growth under appropriate moisture and temperature conditions, resulting in the most unpleasant odors, stains, deterioration in products that lead to loss of storage and transportation, allergic reactions, diseases and infections and more. On the other hand, it can give antimicrobial protection, providing long lasting freshness and sense of security and welfare of consumers. Modern way of life and work contributes to the growth of microbes. Rapid development of antimicrobial treatment been notified in recent years. Antimicrobial agents should be effective against microorganisms, but not adversely affect the man and the environment. Should be resistant to care products, keep all the material properties, and of course, simple to use. Act to kill (bactericide) or prevent the development of (bacteristatic) microorganisms. They differ in chemical structure, mode of action (migrating or non-migrating), stability, efficiency, safety, price. Migratory agents diffuses from the product and come in contact with germs, they consume them and destroy the chemical cell (poisons). The disadvantage is that after some time micro-organisms can adapt to them. Best known as bis-chlorinated phenols (triclosan), organic compounds (TBT, tributyl tin oxide), organometallic complexes of heavy metals (Pb, Hg, As, etc), Ag & Cu zeolites, chitin, azalides, antiseptics and others. Non-migrating agents bond to the product and micro-organisms do not consume them, but mechanically attack the cell wall. Remain effective for the entire life of the product and do not create adaptive organisms. These are organofunctional silane, N-halamine, Aegis® technology and more. At first glance it appears easy to accomplish good antimicrobial protection if you have a good antimicrobial agent, but the persistence of such processing is a bigger problem. It should not be ignored that all available agents are not dermatological acceptable. Antimicrobial treatment in textiles are commonly used for hosiery, sportswear and work clothes, shirts, towels, underwear and other textiles for bedrooms, hygiene and medical (surgery), textile, inside shoes, filters, geotextiles, wipes, dusters and more [5-14].

Since textile can provide good antimicrobial protection, long lasting freshness and sense of security, in this paper the possibility to protect from diabetic foot infection with modified cotton socks. For protective socks it is important that they have no seams on the fingers and not adhering to the foot, in order to reduce friction and skin irritation,

should be made of the finest fibers that effectively control the moisture, in order to provide the highest possible level of comfort [13-16].

2. MATERIALS AND METHODS

This paper deals with the possible protection from diabetic foot infection with the socks made of modified cotton yarn by natural minerals (Sample NM) and active carbon Sample AC). The socks were made on a single knitting machine in the Croatian company Angel tim, Samobor having mass per surface area 241 g/m^2 and compared with regular cotton socks (Sample CS). For durability testing, fabrics were washed 15 times according to ISO 6330:2012.
The antimicrobial protection against Gram positive *Staphylococcus aureus* and Gram negative *Klebsiella pneumoniae* bacteria was determined according to EN ISO 20645:2004, and to micro fungus *Candida albicans* according to EN 14119:2003. Both of these methods are based on creation of inhibition zone, *H*, that can be calculated from according to the equation (1) from Specimen diameter, *d*, and Specimen activity, *D*:

$$H = \frac{D-d}{2}[mm] \quad (1)$$

The fabric hand and sweating were tested *in vivo* according to AATCC Evaluation Procedure 5-2011 *Guidelines for the Subjective Evaluation of Fabric Hand.* For the purpose of *in vivo* measurement 10 diabetic patients were selected - 3 IDDM, 4 NIDDM, 3 GDM. The evaluators performed subjective hand evaluation and ranked fabrics by the physical attributes of hand. *In vivo* diabetic patients evaluated sweating during wearing the socks for 10 hours. The results were compared to the water adsorption presented previously [14].

2. RESULTS AND DISCUSSION

The possibility to protect from diabetic foot infection with the socks made of modified cotton yarn by natural minerals and active carbon was researched. Therefore, the antimicrobial activity, fabric hand and sweating were tested and compared with experimental data previously presented [14], to accomplish the highest possible level its comfort of diabetic patients.
The socks antimicrobial properties against Gram positive *Staphylococcus aureus* and Gram negative *Klebsiella pneumoniae* bacteria was determined according to EN ISO 20645:2004, and to micro fungus *Candida albicans* according to EN 14119:2003. The results are presented in Table 1.

Table 1: Antimicrobial activity to Gram positive, Gram negative bacteria and micro fungi before and after 15 washing cycles

Sample	*Staphylococcus aureus*		*Klebsiella pneumoniae*		*Candida albicans*	
	Activity	H [mm]	Activity	H [mm]	Activity	H [mm]
CS	-	0	-	0	-	0
NM	+/+	0	+/+	0	+/+	0,5/0,4
AC	+/+	0	+/+	0	+/+	0,5/0,5

According to the standards it is necessary to move the test samples from substrate to determine activity. That means that it is not necessarily to have the inhibition zone for antimicrobial activity, and it is sufficient that under the sample the culture did not grow. From the results shown in Table 1 is evident that unmodified cotton socks (CS) do not show any activity to any microorganism. Modification of cotton yarn with natural minerals (NM) and active carbon (AC) results in minor antibacterial activity to Gram positive *Staphylococcus aureus*. On the other hand, there is a significant activity to the Gram negative bacterium *Klebsiella pneumoniae*. All socks made from a modified cotton yarn, regardless of natural minerals and active carbon, show significant activity against micro fungus *Candida albicans*. It should be noted stronger activity using modified activated carbon yarn, which comply with EN 14119:2003 show not only activity, but also a zone of inhibition. Considering durability, it is to point out that this protective ability stays unchanged even after 15 washing cycles.
The fabric hand and sweat were tested *in vivo* before and after 15 washing cycles. Ten diabetic patients - 3 IDDM, 4 NIDDM and 3 GDM, tested fabric hand according to AATCC EP 5 guidelines. The results are collected in Table 2 and compared to *in vitro* measurement of dynamic friction coefficient [14].

Table 2: Subjective evaluation of fabric hand of modified cotton socks before and after 15 washing cycles

Fabric	*In vivo* – Attributes of subjective evaluation of fabric hand				μ_{kin}*
	Compression	Bending	Shearing	Surface	
CS	softer/soft	limp/limp	firm/firm	smooth/smooth	0.260/0.265
NM	soft/soft	limp/limp	firm/firm	little bit rough/smooth	0.255/0.249
AC	soft/soft	limp/limp	firm/firm	little bit rough/smooth	0.244/0.240

**In vitro* measurement of dynamic friction coefficient, μ_{kin} on FRICTORQ [14]

From the results presented in Table 2 it is quite evident the cotton yarn modification effects fabric hand. All the evaluators reported that unmodified cotton socks are slightly softer having smooth surface that modified ones regardless of particles for cotton yarn modification. Even though the natural minerals and active carbon particles are incorporated in cotton yarn structure, the dynamic friction coefficient was almost the same as on unmodified cotton socks. These attributes equalize with the wearing and washing; all the cotton socks after 15 washing cycles become soft and smooth. It is to assume that some particles of natural mineral and active carbon incorporated in cotton yarn wash out resulting in better hand of cotton socks. The objective measurement of dynamic coefficient of friction [14] confirms that. After 15 cycles washing of modified cotton socks all the coefficients resulted in lower value, confirming lower friction and better hand. Contrary, it is evident that unmodified cotton socks have higher friction coefficient as a result of weariness'.

Ten diabetic patients (3 IDDM, 4 NIDDM, 3 GDM) tested socks *in vivo* for 10 hours and reported subjective above the sweat and odor before and after 15 washing cycles. The results are collected in Table 3 and compared to the moisture content objective measurement of water [14]. Subjective assessment of comfort by 10 diabetic patients led to the same conclusion regardless on type of diabetes – IDDM, NIDDM, GDM. In unmodified cotton socks they sweat a lot having odor after 10 h, while wearing the modified ones they did not sweat and there was no odor regardless on particles used for

cotton yarn modification. The reason for that is better absorbency and perspiration which lead to sweat adsorption and no odor occurred. Additionally, the pregnant women having gestational diabetes mellitus (GDM) have reported of not having micro fungi on their feet like most of the other pregnant women stationed in the same hospital.

Table 4: Adsorbility of modified cotton socks before and after 15 washing cycles

Fabric	Sweat / 10 h	Odor / 10 h	WRV* [%/1 g sock]
CS	Sweat a lot/ Sweat a lot	Odor/Odor	31.0/25.5
NM	No sweat/Sweat	No odor/Odor	33.1/30.1
AC	No sweat/No sweat	No odor/No odor	39.2/38.6

**In vitro* measurement of Water Retention Value, WRV [14]

Similar results showed objective measurements of water adsorption [14]. Adsorption of water occurs primarily on the available-OH groups in cotton cellulose in available surface area. Surface area increment resulted in higher cotton adsorption. Therefore, modified cotton yarn adsorbs 32% of water for natural minerals and even 39% for activated carbon. It is to point out that these properties remain even after 15 washing cycles.

4. CONCLUSION

Socks made from standard cotton yarn provide some comfort but do not provide antimicrobial protection. Modifying yarn with natural minerals and activated carbon antimicrobial protection can be achieved, particularly against micro fungi *Candida albicans*. The protection is better for the cotton socks modified with activated carbon. At the same time, those socks show better adsorption and almost the same or even better lower friction which leads to better comfort. The achieved properties remain even after 15 washing cycles. All diabetic patients that tested in vivo modified cotton socks reported of better comfort and freshness regardless of diabetes type. Therefore, it is to recommend using such modified cotton socks for all those who lead active and healthy life, as well as diabetes patients.

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Acknowledgements

This research was partially supported by the Ministry of Science, Education and Sports of the Republic of Croatia. The authors thank to the company Angel tim for the collaboration. Angel tim company from Samobor, Croatia, has long tradition of socks production for male, female, children, baby and special purposes.

STUDY OF THE CONCENTRATION OF WORKERS IN THE COURSE OF DAILY AND NIGHT WORK

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Abstract

The concentration of workers, motor vehicle drivers, who work throughout the day and night was investigated. The chosen method was survey of respondents. It was found that there are differences in time to complete the survey and the accuracy of responses among workers in day and night shift.

Keywords: concentration, survey, worker, daily and night shift

1. INTRODUCTION

Work between 22 hours in the evening and 6 o'clock in the morning of the next day, and in agriculture between 22 hours at night and 5 am the next day is considered night work, if in a particular case or according to other laws, other regulations, collective agreement or agreement between the employer and the works council has not been specified otherwise. Night work is more difficult than daily work due to the disruption of biological rhythm of workers. This increases the psychological stress and fatigue of workers and reduces caution. Reducing caution increases the possibility of accidents. For a better rest of workers, if possible, they should constantly rotate between night and day work shifts (Article 59, paragraph 2 of the Labour Act). The worker should work at night consecutively for a week.

2. BASIC TERMS

Worker - a natural person employed performs certain tasks for the employer (Labour Act, Official Gazette no.149 / 09 Art. 8, paragraph 1).
Driver - a person who drives a vehicle on the road, or a vehicle designed to move across the road (the Law on Road Traffic Safety, Official Gazette no. 48/10, Article 2, Paragraph 66).
Night work is the work between 22 hours and 6 hours of the next morning, and in agriculture between 22 hours and 5 hours of the next morning, except for the case that Labour Act or other laws, other regulations, collective agreement or agreement between the employer and the works council otherwise specify (Labour Act, Official Gazette no. 149 / 09 Art. 59, paragraph 1).

2.1 Concentration

Concentration is a term used to describe our ability to direct our mind in the desired direction.
A healthy man can focus on something for a certain time until it comes to fatigue, excess or boredom. However, in some situations the maintenance of concentration is of the utmost importance for a person, such as driving.
This is the reason why it is important to know the factors affecting the concentration and ways of its maintenance at the required level.

3. RESEARCH

3.1. Research problem

The problem of this study was to find out whether and to what extent there is a difference in the concentration of workers during the day and night work. The level of concentration of each worker is subjective information. Therefore it was necessary to do the research that will show the concentration of thoughts of each worker on a specific parameter. In this case, it was accuracy and speed of identification of traffic rules by drivers during day and night work.

3.2. The aim of the research

The aim of the research is to see whether there is, if so, and to what extent, a difference in the level of concentration of workers during day and night shifts. In this case the investigation will be carried out on drivers. The survey to be carried out for the purposes of investigation is composed of questions about the rules of road traffic safety. Each professional driver should be familiar with these rules. Therefore, the time necessary for each worker to solve the survey will be measured.

3.3. Hypothesis

Hypothesis: Concentration of workers during night and daily work should be different and it should be higher by day than at night. Human ability to concentrate and maintain concentration at a high level should be higher during the day because of the biological rhythm of man. However, all people are not equal and all of them do not have the same biological rhythm. The ability to maintain concentration depends on many factors, such as thirst, hunger, or the amount of food consumed, stress, fatigue, environment, motivation, health, etc. It is fatigue that should represent the greatest reason for the decline of concentration during night because it is foresee to take a rest at night. At night a person becomes more fatigued because the night is not a natural part of the day when one should work
Appropriate actions, primarily plenty of rest, will enable the worker to be prepared for night work and thus prevent lack of concentration. And this is extremely important, because lack of concentration leads to reduced caution which increases the possibility of accidents. Lack of concentration causes unreadiness to respond quickly when necessary.

3.4. Survey methodology

The survey was carried out on a sample of 10 drivers during day shift and 10 drivers during night shift, who had to solve the questionnaire with questions about road traffic safety. Since each driver with a permit knows exactly how to solve such tests, the time required to solve the exam was measured. According to the time required for completing the survey, the result will show a difference in concentration of drivers working in day shift compared to those working in night shift. The survey was conducted at a gas highway station where drivers stop for call of nature, but also to take a rest. Before conducting a survey the purpose and objective of this research were explained to each driver, and they were acquainted with the method of conducting a survey. They were also asked to fill in the questionnaire seriously and not to worry about the results or about some of their other problems and concerns. When selecting questions for the survey, those questions were selected that are related to actions which drivers use every day. All questions for which the answer can vary according to the category of driving license or transport vehicle were avoided. The questions for which there are multiple correct answers were also avoided in order to prevent long-term thinking about the answer. Workers were divided into two groups. Day shift workers were in the first group, while night shift workers were assigned to the second group.

3.5. Results of the survey

Tables 1 and 2 show the results obtained by conducting a survey of workers:

Table 1. Results of the survey of the first group

First group (day shift)			
Respondent	Percentage of correct answers [%]	Percentage of incorrect answers [%]	Time necessary for solving [seconds]
Driver 1	100	0	272
Driver 2	100	0	281
Driver 3	100	0	265
Driver 4	100	0	277
Driver 5	100	0	263
Driver 6	100	0	275
Driver 7	100	0	269
Driver 8	100	0	256
Driver 9	100	0	270
Driver 10	100	0	267
Average	100	0	269.5

Table 2. Results of the survey of the second group

Second group (night shift)			
Respondent	Percentage of correct answers [%]	Percentage of incorrect answers	Time necessary for answers
Driver 1	100	0	271
Driver 2	100	0	280
Driver 3	100	0	266
Driver 4	100	0	273
Driver 5	90	10	261
Driver 6	95	5	282
Driver 7	100	0	290
Driver 8	100	0	265
Driver 9	100	0	269
Driver 10	100	0	268
Average	98.5	1.5	272.5

4.PROCESSING,ANALYSIS AND DISPLAY OF DATA

Survey questions applied to the field of traffic safety, i.e. areas directly related to the driver's job. For each of the questions three answers were offered, of which only one was correct. In this way it was easier to give answers and unnecessary confusion of surveyed workers was avoided.

As the questions were selected in such a way that each professional driver should know how to solve everything exactly, the time required for each respondent to solve the survey was measured.

As it had been expected, on average, the day shift workers solved the survey faster than the night shift workers. Day shift workers needed to solve the survey 269.5 seconds on average, while the night shift workers needed 272.5 seconds on average, Figure 1. Although the difference is only three seconds, which is very important in traffic because one second is sufficient for an accident with serious consequences.

Although it was not expected, the survey showed that there is a difference in the accuracy of the answers, as we can see in the chart, Figure 2. While the day shift workers had all the correct answers, in the night shift two respondents gave one and two incorrect answers, respectively.

The questions with incorrect answers given by the respondents were no. 5 and 7:

Question 5:

Due to taking medication with a red triangle on the package driving is forbidden:

a) at least 4 hours, b) at least 1 hour, c) at least 2 hours

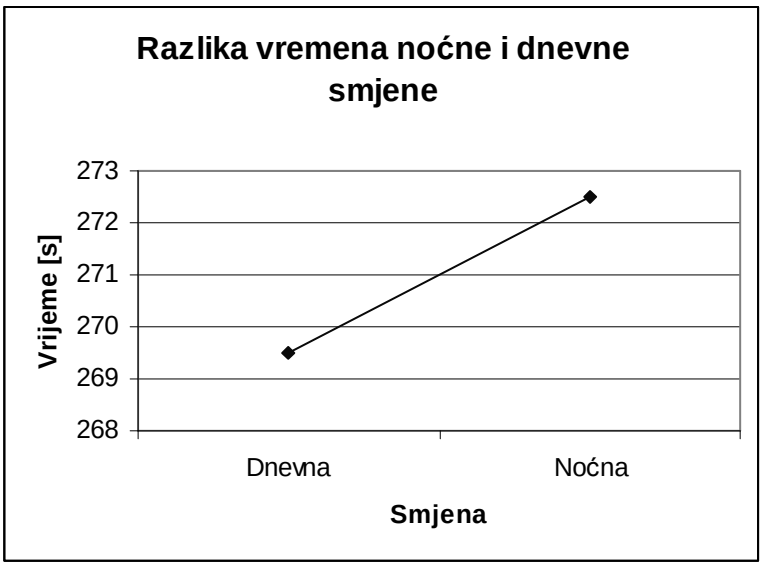

Figure 1. Graph of the time difference by shifts

E.:Razlika - Time difference between night and day shift,vrijeme - time ,dnevna – day, noćna - night ,smjena - shift

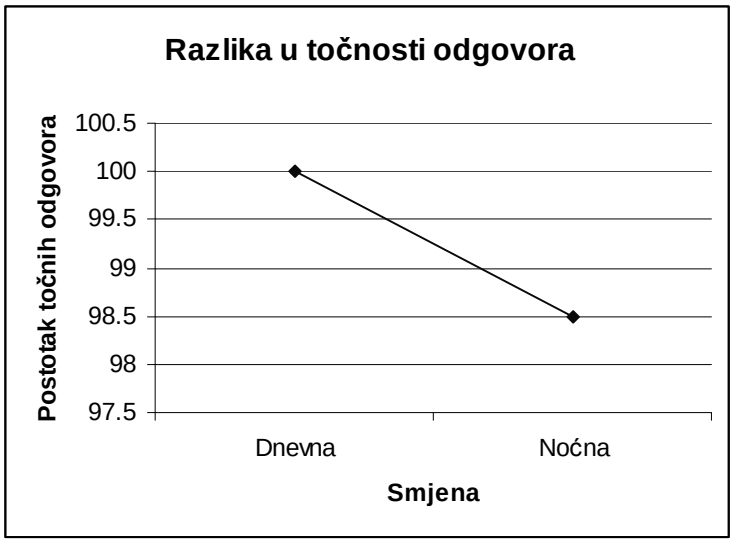

Figure 2. Graph of the difference in answer accuracy

E.:Razlika u točnosti - difference an answer accuracy,postotak točnih odgovora - Percentage of correct answers,vrijeme - time ,dnevna – day,noćna - night ,smjena - shift

Question 7:
On public roads stopping and parking is only allowed on the designated areas outside the roadway, but in the case of a vehicle defect or an accident you must set the mark in the shape of a triangle at a distance of:
a) 25 m, b) 50 m, c) 75 m

As the two respondents did not directly encounter answers to these questions, the results from the survey will be attributed to their ignorance of regulations rather than to lack of concentration due to night shift work. They were told about the inaccuracy of answers. Each driver got acquainted with the regulations of road traffic safety during driver's education. Ignorance of these regulations may cause an accident, and this is the reason why they should be occasionally repeated. If necessary, the employer should prepare knowledge verification of road traffic safety for those drivers who are directly related to traffic.

5. CONCLUSION

The survey showed that there is a difference in the time needed to solve the survey between day and night shift workers. It is this difference in speed that indicates the difference in the level of concentration. These results were expected, because night work generally adversely affects the physical condition of workers, increases stress, nervous and depressed states, as well as chronic fatigue and lack of sleep.
Man can focus on something for a specific time, until it comes to fatigue. However, in some situations, maintaining concentration is of the utmost importance for a person. Such a case is driving because the slightest lack of concentration can lead to an accident. It is therefore necessary to know the techniques and ways to improve and maintain concentration on a high level. Before work every worker, especially if he works in the night shift, should take enough rest. Before setting out the driver should eat and drink enough because hunger and thirst increase fatigue and reduce concentration. While driving fresh air should be let into the cabin several times because it will stimulate the brain to watchfulness. When the driver feels that fatigue turns into drowsiness, he had better stop at the nearest roadhouse and take a short break during which he walks, drinks coffee or does something else which will awaken him and raise his level of concentration. And it is important all the time to keep in mind the ultimate goal and purpose of driving, but also the job that is performed because motivation significantly affects the level of concentration of each man.

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THE EXPOSURE TO THE CARCINOGEN DUST IN TIMBER INDUSTRY

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Summary
Previous studies of worker exposure to wood dust in the workplace, both in our country and other countries were determined by the mass concentrations of respirable particles and total dust. Based on previous studies, the results show that more than half of the work places exposures are greater than the prescribed limit. This paperwill note which tree species cause tumour of the nasal cavity, other disorders, allergies, and asthmas, etc.

Key words: wood dust, Inhalable fraction

1. INTRODUCTION

Working with sprockets saws, workers have to work felling and processing, with a load of noise and vibration, further burdened by adverse effects of exhaust gases and particulate mineral oil and wood dust from the working atmosphere. Due to long exposure to wood dust, at low concentrations, the chemical composition of wood materials can have very strong biological effect on human health. Besides the occurrence of allergies and asthma, due to harmful substances from pine, spruce and oak the biggest problem is the risk of developing adenocarcinoma of the nose and sinuses caused by exposure to wood dust, beech and oak. The emergence of developing adenocarcinoma of the nasal cavity in the wood industry workers is very significant in relation to the occurrence of other malignancies of the total human population, which is very rare and is only 0.25%.It is not entirely sure that the chemical composition of wood substance has carcinogenic effect, but given the importance of the content of tannin, tannin acids, aldehydes and its oxidation products, as a result of mechanical processing at high heat generated chemically altered charred wood particles. To assess the harmfulness of wood dust it is significant the one that reserves in the ambient air particulate matter consisting of up to 100 μm aerodynamic diameter before the sedimentation. Professional exposure to organic dust is still present in many workplaces. The term organic dust refers to a mixture aerosol particles of plant, animal

and microbial origin. It can cause or worsen a variety of inflammatory disorders of the respiratory system, the irritating symptoms of upper and lower respiratory tract to asthma, chronic obstructive lung disease, byssinosis, hypersensitivity pneumonitis and organic dust toxic syndrome.

2. WOOD DUST

Dust is a solid dispersion consisting of aerosol particle size of <1 to 100 um. Most of the wood particles mean aerodynamic diameter greater than 5 mm (135). The airways are observed separate areas which differ according to the method of removal of inhaled particles, and particle residence time at the site of deposition.

The air is purified entering the body when going through the input part of the respiratory system.Coarse particles are stopped by the nasal hairs or deposited on the mucous membranes of the nose, pharynx and throat after which it can be mechanically removedby sneezing, wiping noses or swallowing. Smaller particles penetrate deeper into the respiratory system. Previous studies have shown that the disposal of particles in the respiratory system can be displayed as a function of particle aerodynamic diameter.

International Organization for Standardization (ISO) has introduced five fractions of particles as a function of the probability of penetration in certain parts of the respiratory system:

1. Inhalable fraction - mass of particles that enter the respiratory system when appropriate.
2. Extrathoracic fraction - mass of inhalable particles do not penetrate deeper than the larynx (aerodynamic equivalent diameter of particles> 10μm).
3. Thoracic fraction - mass of inhalable particles that penetrate deeper than the larynx.
4. Tracheobronchial fraction - mass of inhalable particles that penetrate deeper into the larynx, they penetrate deeper than the terminal bronchioles (aerodynamic equivalent diameter of the particle 3-15μm).
5. Respirable fraction - mass of inhalable particles that penetrate the alveolar spaces (aerodynamic equivalent diameter of particles <0.2 - 10μm).

Wood dust has irritating and allergenic properties. One example is the allergicallyplicatic acid that is released during the processing of red cedar (Thuja plicata). Exposure to high concentrations of allergens is associated with an increased prevalence of asthma among workers.

It is assumed that the mechanisms that lead to the development of asthma in exposed workers are not only allergic nature.Although he found the increase of specific IgE antibodies to plicatic acid in exposed workers with a positive correlation between the concentration of these antibodies and the incidence of bronchial hyper-responsiveness (BHR), increased prevalence of BHR was found in neatopic workers. Seems to be allergenic and irritant properties owned and catechol from oak (Quercussp) and

sesquiterpenes from beech (Fagussp), which is associated with an increased incidence of BHR in exposed workers.

3. EFFECTS OF EXPOSURE TO ORIGANIC DUST IN THE WORKING ENVIRNMENT IN TIMBER INDUSTRY

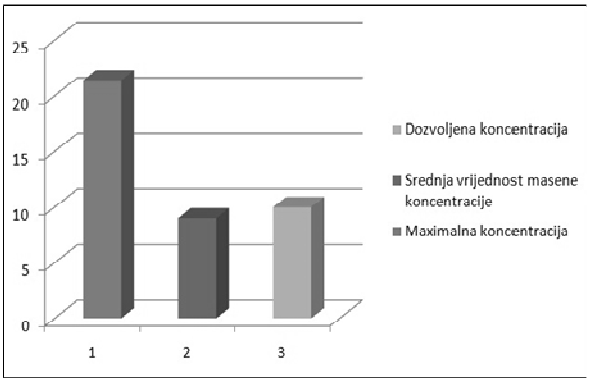
Wood industry, as well as many jobs in other industries, such as textiles and food processing, agriculture, livestock farms and forestry; involve significant exposure to organic dust. Organic dust can be defined as a mixture of particles aerosol plant, animal and microbial origin. Workers in the timber industry, for example, are exposed to wood dust and volatile substances that are released when wood processing (e.g. terpenes, catechol, and plicatic abietic acid), bacteria and spores of various types of moulds and their decomposing products, including endotoxin and beta glucan, pesticides which wood is treated to protect against parasites, and metals which are released from the surface of the cutting machines.

PICTURE 1- bend saw blade-blade of unalloyed or low-alloy steel

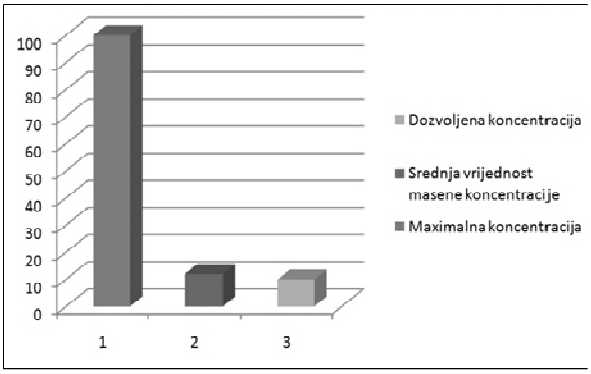
In the following example, there are the results of investigations of wood dust in the factory flooring. When we sampled and determinate dust we used recommendations company Casella CEL and their website http://airsamplingsolutions.com/ used. In the process of sanding wooden floors in the operation of the company frees up a considerable amount of dust. Workers are exposed to constant during their full-time job to petty respirable dust and they avoid wearing personal protective equipment, which they are secured by.

PICTURE 2-Personal protective means are used for protection from respirable dust

To determine the amount of the presence of dust in the workplace dust measurements were performed on two occasions. The measurement is carried out using the direct method of reading instrument MicroDust 880. The first measurement was made on the first day for 10 minutes. Concentration reached a maximum of up to 21.4 mg/m3. The average (mean) value of the mass concentration of total dust was 9.00 mg/m3 which does not exceed the maximum allowable concentration of wood dust is 10.00 mg/m3. Another measure in the same job operation was repeated the next day. Measurement is made by direct indication of mean mass concentration of total dust for 30 minutes and when it has reached a maximum concentration of 100.00 mg/m3, whereas the mean value of the mass concentration of total dust was 12.00 mg/m3, which amounts to more than the maximum allowable concentration of 10.00 mg/m3.



PICTURE 3- Measuring the presence of dust for the first time in about 10 minutes



PICTURE 4-Measuring the presence of dust, the second time for 30 minutes

The results showed that, depending on the duration of the measurements in one case we get the value of which, according to our current standard of the permitted MRL, and in the second case the measurement time extended to 30 minutes,mean for the average concentration of dust has exceeded the limit. Besides the extension of the time of sampling, the maximum concentration of 100 mg/m3, which is significantly higher than the value of 20 mg/m3, recommended by the British Standard MDHS14 / 3 for short-term exposure limits (STEL) for cellulosic total dust inhalation.

As recommended by the British Standards MDHS14 / 3 short-term exposures limit (STEL), which is defined as a 15-minute TWA (weighted average value of the observed time interval) exposure that should not be exceeded during a workday even if the 8-hour reference TWA is within limits. Exposure to the STEL should not be longer than 15 minutes and should not be repeated more than 4 times a day.You should pass at least 60 minutes between successive exposures at the STEL.So from these previous considerations, one can clearly see that the value of 10.00 mg/m3, prescribed by JUS.Z.B0.001/1991 for MRLs for wood dust remains very poor in the context of the considerations above, especially for the workers' safetythat are endangered in the work process where mentioned dust is present.

4. HEALTH EFFECTS OF OCCUPATIONAL EXPOSURE TO RESPIRATORY HAZARDS IN TIMBER INDUSTRY

Exposure to organic wood dust can cause acute and chronic respiratory disorders, irritative symptoms of upper and lower respiratory tract to asthma, COPD, hypersensitivity pneumonitis and organic dust toxic syndrome (4, 5, 134). Wood dust, primarily from hard wood species (e.g. Oak and beech) can have carcinogenic effects, and is associated with the development of cancer of the nasal cavity and sinuses.

Asthma is a disease characterized by varying disturbances in the flow of air through the airways and / or hyper-reactivity of the airways accompanied by inflammation. Occupational asthma refers to cases of asthma caused by the inhalation hazard in the workplace (4). Occupational asthma may be allergic and irritating, distinguishing between two forms of irritating asthma. The first is reactive airways dysfunction syndrome (RADS) which occurs suddenly after a short exposure (usually accidental) high concentrations of gases, vapours, fumes or dust that act as respiratory irritants, and to the people who had never suffered from asthma. Another form of professional irritating asthma is induced by prolonged exposure to irritating astmogenic substances in concentrations much lower than those that cause RADS. Allergens liable for the development of allergic asthma are numerous, and their chemical compositions are usually proteins. The molecular weight can be divided into high molecular weight (> 5000 Daltons, e.g. dust mites, latex, mould, coffee, flour) and low molecular weight (<5,000 Daltons, e.g. diizocyanate, acid anhydrides, metals, penicillin. The low molecular weight allergens include and abietic and plicatic acids that are released when processing wood.

Chronic obstructive pulmonary disease is characterized by restricted air flow through the airway that is not fully reversible (4). Flow limitation is usually progressive and associated with (probably genetically based) excessive inflammatory response in the airways and lung parenchyma caused by inhalation of noxious gases or particles. Chronic obstruction of the airway is caused by the pathological changes in the small airways (obstructive bronchiolitis) and deterioration of lung parenchyma (emphysema). This disease is one of the leading public health problems, and by the predictions of the World Health Organization will become the third cause of death and the fifth leading cause of work disability in the world by 2020. Costs of treating COPD triple exceed the costs of treating asthma (158). In developed countries the most common cause of the origin and development of COPD is cigarette smoking, but also air pollution, diet

deficient in protein, as well as occupational exposure respiratory hazards, including wood dust.

Byssinosis is also included in the group of professional lung diseases caused by inhaling dust with biologically active vegetable origin as it is cotton, hemp and linen.At the beginning of the disease is manifested by coughing, chest tightness and shortness of breath on the first working day of the week after a week of rest, and over time these symptoms persist throughout the work week and the disease goes into COPD.

Hypersensitivity pneumonitis (extrinsic allergic alveolitis) is accompanied by an inflammatory reaction in alveoli and terminal bronchiole after previous sensitization and repeated inhalation of organic dust (farmer's lung, pigeon breeder's disease).

5. CONCLUSION

It has already been pointed out that the determination of the concentration and duration of exposure to respirable dust of most concern in the professional pathology. The methods of work, analysis of working atmosphere, the whole methodology and procedure for the analysis should be determinated. Personal sampling dust with the constant analysis of the results should be a central part of the safety and health at work for each extraction of minerals or the treatment processes where dust occurs.
When selecting maximum risk workers important factors are the following:

- Closeness to sources of contaminants (pollutants),
-The frequency of closeness to sources of contaminants,
- Number of sources of contaminants,
- Workers' complaints and diseases.

Suspicious and potential health hazards can be assessed by sampling the greatest dangers workers - persons who is considered to have the greatest potential for exposure. A worker can be exposed to high risk, due to the work area (location) or procedures of work (tasks). Work area can have more than one maximum risk if work activities or operations are not uniformed or if there are several different sources of exposure.

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THE IMPACT OF ANTHROPOMETRIC CHARACTERISTICS AND POSITION OF THE SCHOOL CHAIR SEAT AT THE LOAD OF STUDENT'S SPINE

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Abstract

This paper analyzes the load segments-vertebral lumbar-sacral region of the spine at L4 and L5 caused by changing anthropometric characteristics like body weight and height of students for three categories: normal subjects, obese and malnourished subject entities. The load analysis is carried out for five different seating positions, in a function of a tilt-felling seating from 0 degree to a maximum of 15 degrees, while individual forces and moments of varying sizes (AnteroPosterior force, MedioLateral force and ProximoDistal force) occur at L4 and L5, with the highest intensity of ProximoDistal force which is highly expressed at obese and tall subjects and during the felling of seats the force rises from 0 degree to 15 degrees, and the highest value of the force is at the seating positions in (3) and (4) which is 371,3 [N], and the largest load torque of 12[Nm] at L4 and L5 is in this option.

Key words: *anthropometry, school furniture, biomechanics*

1. INTRODUCTION

There are a number of elements in and around the student to comprehend, which influence the final form of school furniture. Although school furniture is not the only impact and even more it is not direct impact that causes irregularities in posture and strains of the student's body (scoliosis, kyphosis), unfavorable conditions for sitting certainly adversely affect the growth and development of students. Long hours of sitting in school adversely affect the physical as well as mental development of the students. The fact that the students' violent behavior increasingly present cannot be denied, but it raises the question of looking at the reasons why students act so "inappropriate."

The emergence of such "aggression" lies in the statement that they are sitting in inhumane and inappropriate schools as well as in dilapidated and outdated classrooms with inadequate shaped furniture. Outside regular school hours the students are sitting on the floor, stairs, wall etc. because they have no other options. That is why there is a kind of partly passive resistance, but more frequent and aggressive one.

Student's body is not constructed for sitting but for moving, and when the students are awake in school they spend more than 30% of the time usually sitting .It is obvious that the problem the students have will increase in the future, so we need to experience school as a student's workplace. In practice, there are different approaches to the consideration of the interaction of furniture and customers thus "restlessness" on the school chair is prohibited while dynamic sitting on the office chair is recommended which causes different effects on the health of the spine.

2. RESEARCH PROBLEM

The chairs with a seat made of glued beech veneer (veneer pressings that have no desirable softness of the seat) are mainly used in schools. Because of the hardness present in a veneer molded part and the actual biomechanics of seating, students are getting one selves into a situation(position) of limited work applicability due to the present problems in diseases of the lumbar spine, even before the end of secondary education, and the issue of "comfort" of the seat practically raises there. Before analyzing the seating position, in other words how the angle of the seat during the sitting can be changed, it would be advisable to categorize the seating positions depending on the center of gravity as well as to define the body positions during the sitting.

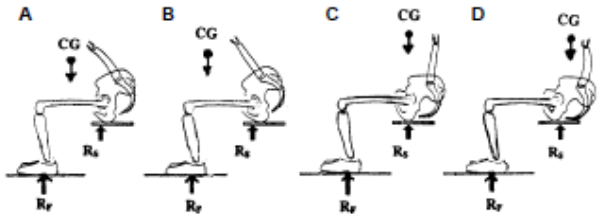


Figure 1: Schoberth's categorization of the sitting position based on the center of gravity of the body

Analyzing the sitting position vector Rs represents force reaction that occurs in the seat and its direction is opposite to the force of gravity; vector Rf represents substratum force in relation to the_foot and CG is the center of gravity of the body mass of the subject and is slightly above the pelvis. In the central position (C) center of gravity (CG) is slightly above L4 L5 segments, while the feet carry –transfer about 25% of body weight onto the floor. The spinal (vertebral) column is nearly straight or slightly curved in the central position. If we want to change our position, from the central to the front one, we can do that either by changing the angle of the pelvic bones and the spinal column (B) or by curving the spinal column (A) without major changes of the angle between the pelvis and spinal column. In front position gravity is in front of L4 L5 segments, and your feet transfer a little bit over 25% of body weight onto the floor. In rear –final back position (D) gravity is slightly above or behind L4 L5 region, while the feet transfer less than 25% of body weight onto the floor. Through a series of studies it has been arrived at a conclusion that the internal pressure between the vertebrae is significantly higher at improper sitting position than in standing position.

3. METHODOLOGY

The focus of the analysis is sitting at school desks, in fact the focus of the analysis is design of school chair. Former classic image of this furniture is that the chair is created from wood, without specially designed areas for specific regions of the body, and the back rests are at the angle of 90 degrees or slightly above 90-95 degrees.
We are going to start from the above analysis, discussion, past experiences and try to do a step forward in the optimization and ergonomic design environment in order to get a higher comfort at the school population. The subject is placed in a sitting position. Gluteal region and backs lean on the chair seat and the back of the chair. The legs are resting on the floor. When the hands are on the table (school desk), the mass which is transferred onto the floor is within the limits of 25% of body weight. A head rest is not taken into consideration. A desktop -school desks will be used instead of the characteristic arm rest. The upper body is upright and straight. The angle to the pelvis with a vertical plane is 0.05 degrees. Femora are in horizontal position and feet are resting flat on the floor. Analysis will be carried out through a series of steps from the initial to the final position. We will consider five positions where the seat moves for 3.75 degrees, the legs move for 2.5 degrees, the pelvis move for 0.05 degrees in each new position to spine gets appropriate form.
We will consider three cases which may be taken as representative of the population, namely, the one subject of normal weight and height (75 kg, 175 cm), obese subject weight 95 kg and height of 180 cm and a representative of the population with the problem of malnutrition, weight 55 kg and height 170 cm. Relative error of scheduling weight of the body occurs because of Any Body Modeling software package. The software considers the weight is evenly distributed to the entire body. The conventional representation of mass index has the same disadvantage because of BMI (Body Mass Index). BMI does not show the mass segments distribution on the body but the whole mass is divided by height squared.

3.1. Analysis of the force and torque on the vertebrae L4 L5

The main goal of this research is to look for the loads that govern the body depending on the sitting positions, Figure 2. Hence, we are going to look only to the skeletal muscle model of a human being. The seat, back support, arms and feet support are taken as the mating surfaces of the model.

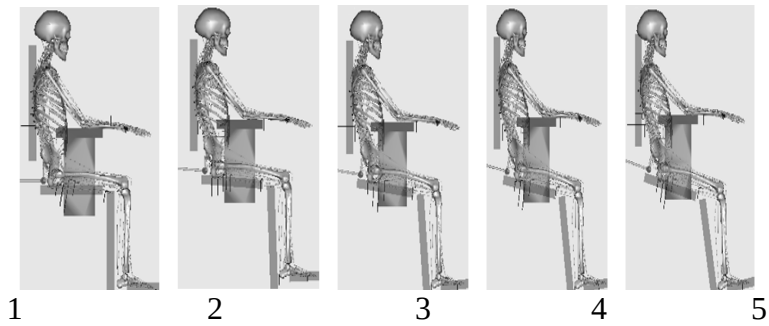
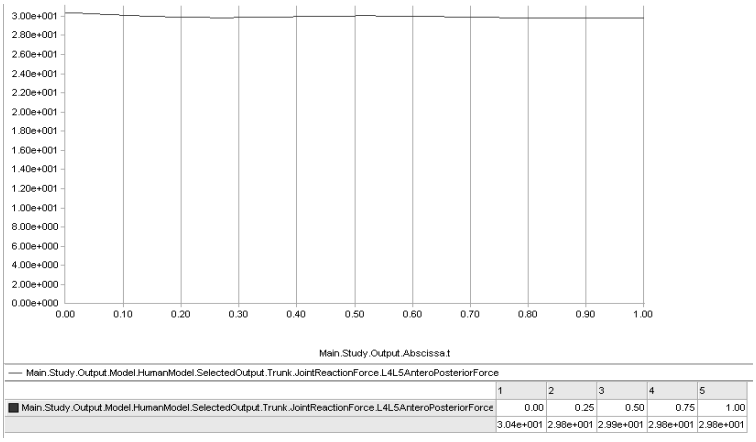


Figure 2: Schematic presentation of sitting positions 1-5 with the change of tilted seat

Figure 2. shows an initial position that will be considered at the research and it is a basic sitting position . At the positions (2-5), we will consider the impact of the seat turning for a positive angle from 0 degree to a maximum of 15 degrees with the remark that the legs move according to the change of the body position for a slightly lower angle so the legs will be shifted for 10 degrees in final position.
As a major determining factor in the seating position is certainly the load of L4 L5 segments. In these segments individual forces and torque occur as a result of different body positions.
The first force that will be mentioned is AnteroPosterior force at L4 L5. In anatomy AnteroPosterior (relating to both front and back) is an area from the front to the back of the segments. In this case it is the action of the force from the front to the back of the vertebrae.
InFigure 3. you can see clearer view of the load flow through the positions (1-5). It is noted that the load for the designated observation is moving up to 3.00e +001 or 30 [N].



	1	2	3	4	5
Main.Study.Output.Model.HumanModel.SelectedOutput.Trunk.JointReactionForce.L4L5AnteroPosteriorForce	0.00	0.25	0.50	0.75	1.00
	3.04e+001	2.98e+001	2.99e+001	2.98e+001	2.98e+001

Figure 3: AnteroPosterior force at L4 and L5

The next load we are going to analyze is the load on L4 L5. In fact we are going to analyze the MedioLateral force. This force acts from the center towards the ends of the segments and will also be shown in Figure 4, which provides an overview of the load flow in the indicated positions (1-5).

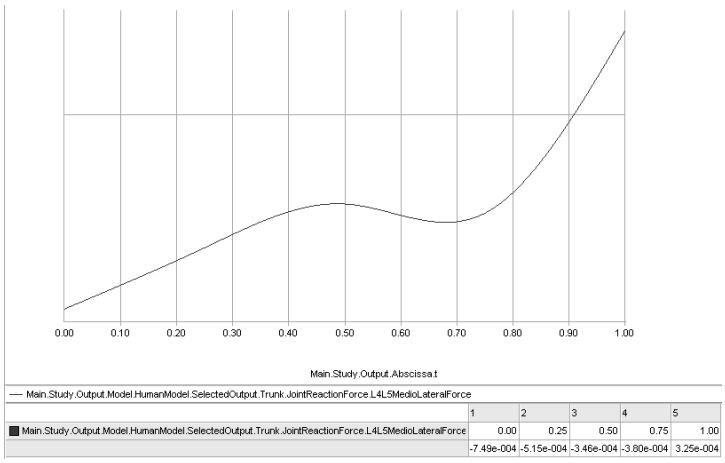


Figure 4: MedioLateral force at L4 and L5

It is noted that in Figure 5 the ordinate has no value because of extremely small sizes of the loads-from 7.48-004 (0.00075) to 3.25-004 (0.000325) so the entire range is actually a narrow area around the 0-value of MedioLateral force.

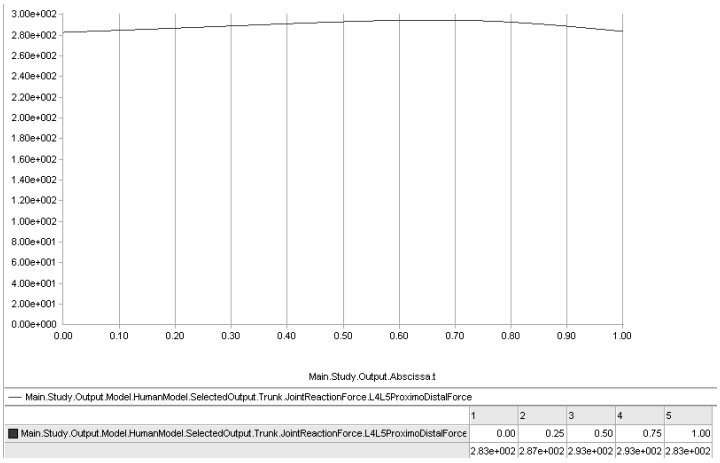
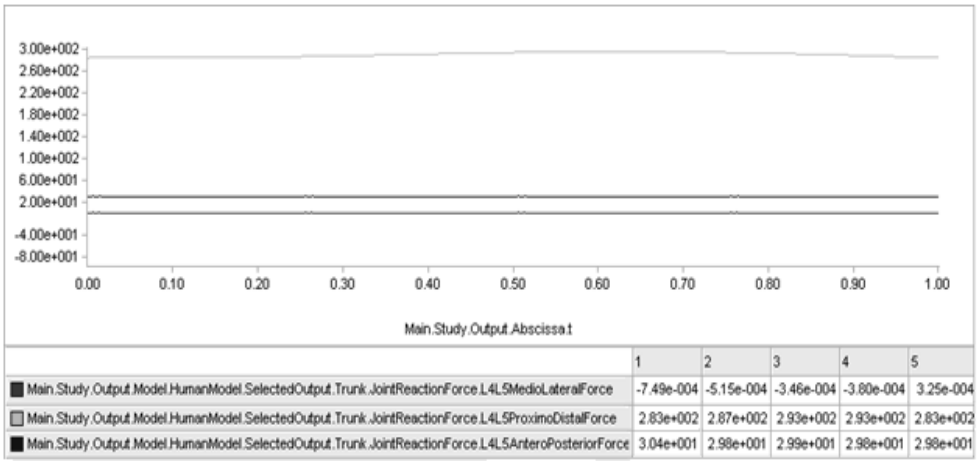


Figure 5: ProximoDistal force at L4 and L5

ProximoDistal force L4 L5 segments is seen from the center to the outermost regions and the segments ends. It is noted that the maximum ProximoDistal force on L4 and L5 is slightly below 300 [N].

The most significant load is by ProximoDistal force; AnteroPosterior force has relatively little impact on the overall load at L4 L5 segments, while MedioLateral force can almost mpletely be ignored since it has the values very close to zero throughout

the simulation . Graphical representation of all loads on segments L4 L5 is given in the following Figure 6.



	1	2	3	4	5
Main.Study.Output.Model.HumanModel.SelectedOutput.Trunk.JointReactionForce.L4L5MedioLateralForce	-7.49e-004	-5.15e-004	-3.46e-004	-3.80e-004	3.25e-004
Main.Study.Output.Model.HumanModel.SelectedOutput.Trunk.JointReactionForce.L4L5ProximoDistalForce	2.83e+002	2.87e+002	2.93e+002	2.93e+002	2.83e+002
Main.Study.Output.Model.HumanModel.SelectedOutput.Trunk.JointReactionForce.L4L5AnteroPosteriorForce	3.04e+001	2.98e+001	2.99e+001	2.98e+001	2.98e+001

Figure 6: Resultant of the action-synthesis of all loads (forces) on the L4 and L5

The influence of anthropometric parameters (weight and height) of the students during sitting is shown through the intensity of three types of loads on L4 and L5 segments (AnteroPosterior force, MedioLateral force and ProximoDistal force)and it is given in the following cases of anthropometric measures of the users, Table 1, Table 2 and Table 3.

Table1. Tabular overview of the forces on L4 and L5 at a malnourished subject-user, depending on the seating positions (1-5)

					Sitting positions of the student				
					1	2	3	4	5
moment	height	mass	Force at L4 L5	Anteroposterior [N]	21.8	21.4	21.4	21.4	21.4
8 [Nm]	170 [cm]	55 [kg]		MedioLateral [N]	-0.0005	-0.0003	-0.0002	-0.0001	0.0003
				ProximoDistal [N]	207.4	210.3	214.7	214.7	207.4

Table 2. Tabular overview of the forces on L4 and L5 at a normal subject-user, depending on the seating positions (1-5)

					Sitting positions of the student				
					1	2	3	4	5
moment	height	mass	Force at L4 L5	Anteroposterior[N]	30.4	29.8	29.9	29.8	29.8
10 [Nm]	175 [cm]	75 [kg]		MedioLateral [N]	-0.0007	-0.0005	-0.0003	-0.0003	0.0003
				ProximoDistal [N]	283	287	293	293	283

Table 3. Tabular overview of the forces on L4 and L5 at an obese subject-user, depending on the seating positions (1-5)

					Sitting positions of the student				
					1	2	3	4	5
moment	height	mass	Force at L4 L5	Anteroposterior[N]	35.0	34.3	34.4	34.3	34.3
12 [Nm]	180 [cm]	95 [kg]		MedioLateral [N]	-0.0009	-0.0007	-0.0005	-0.0003	0.0005
				ProximoDistal [N]	358.6	363.7	371.3	371.3	358.6

4. RESULTS AND DISCUSSION

Based on the analysis of the impact of anthropometric characteristics of the student-body weight and height, as well as changing the position of the school chairs seat from 0 degree to 15 degrees down into five different positions, we have certain changes in intensity of the loads- forces on L4 and L5 vertebrae of lumbar-sacral region of students and it is for sure that ProximoDistal force is the force with maximum intensity and is in the direct function of anthropometric characteristics as well as in the direct function of the chair seat. For obese subjects with body weight of 95 kg and height of 180 cm and for the sitting positions (3) (4) where the seat angle changes from 0 degree to 15 degrees the force is 371.3[N].

Imperative of our time with longer time of the students' sitting -future users as well as the dynamism of the anthropometric characteristics of young population, which changes recognizably every ten years, asks designers, furniture designers and ergonomists to have special approach considering the interaction of students and school chair in order to improve the work usability of the user or retain it at the same level.

The average height of students in secondary schools in Bosnia and Herzegovina in the last twenty years has increased by an average of 5-10 cm.

The interaction of the chair and the student is required; if the student leans forward or backward, school chair should follow the movement, to stimulate the muscles of the back and leg movements in order to optimize the circulation of blood and oxygen supply.

5. CONCLUSION

1. Ergonomic furniture sizes are inappropriate for present population of high school students, and there is a big gap between anthropometry dimensions of students and functional dimensions of furniture.
2. School chair is no longer "a piece of furniture" used for sitting in classroom but it is an important part of anxiometric system. That system should be adapted to the student to allow him/her smooth biomechanical movements as well as to increase his/her concentration and motivation.
3. Standards and other regulations that deal with the area of school furniture should be the basis of work to every constructor, technologist and furniture designer.
4. Solving the problem of comfortable seating lies in the production of school furniture appropriate to different age of students, what means that desks and chairs of various sizes would be found in every classroom so a small amphitheater could be formed.
5. Numerous experts in interdisciplinary fields such as wood technology, ergonomics, design, design pedagogy, orthopedics etc., must be involved in the process of new school furniture developing.

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THE INFLUENCE OF HUMANS ON THE QUALITY OF THE RIVER UNA ENVIRONMENT

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Abstract

The paper presents the impact of humans on the protection of the environment and river Una. River Una is 212 km long and springs near Donja Suvaja and Donji Lapac, flows into the river Sava near Jasenovac, and has been preserved thanks to the high awareness of the population who live on its banks, especially population of Una – Sana Canton. Education of the population in Una-Sana Canton is starting with children in kindergartens and continues throughout elementary and high school. Thanks to the high awareness of the importance of drinking water, river Una has maintained a high glow, and despite the global water pollution water from river Una is used for drinking.

Keywords: river Una, environment, solid waste, humans, ISO 14001.

1. INTRODUCTION

River Una, was named by the ancient Romans, who, when for the first time saw its picturesque beauty and heard the murmur of her waterfalls in Martinbrod, Štrbački Buk and waterfalls in Ripač, exclaimed, "UNA" which in translation means "**the one**", or "**the only one**."

For the cities of Bihać, Martinbrod, Kulen Vakuf, Ripač, Bosanska Krupa, Bosanska Otoka, Bosanski Novi, Kostajnica, Kozarska Dubica and Dvor na Uni the importance of river Una is invaluable, and without it we cannot survive. In these cities, today there are more than 700.000 people in the territory around the river Una, which is over 9,368 km^2. This river has the most beautiful waterfalls in Europe. A large waterfall Štrbački Buk is located in Bosnia and Herzegovina, near the border with Republic of Croatia. Štrbački Buk consists of several waterfalls, close to one another, with the biggest waterfall being about 25 meters high, and it provides a magnificent image in which a person can enjoy. This waterfall is located in a National park Una.

Figure 1: Flow of river Una

Figure 2: Štrbački Buk on river Una

Figures 1 and 2 show the flow of the river Una and her beautiful waterfall Štrbački Buk, located in the heart of the National Park "Una".

2. THE BASIC PRINCIPLES OF THE ENVIRONMENT PROTECTION OF RIVER UNA

Starting with the existential significance of the river Una for the people on its banks, generations of people have established the regulations on water protection in Bosnia and Herzegovina. These regulations define water as a common good, and today the current Water Act, besides determining water as a common good, stipulates special protection of waters by all levels of government in Bosnia and Herzegovina, BH entities, cantons and local governments, cities and municipalities, and prescribes obligations of legal entities and individuals in terms of water and declared it a heritage that must be preserved, protected, and accordingly treated. The population on the banks of the river Una is educated in the field of domestic regulations on water protection. Bearing in mind the water as a resource and the capacity of the environment, the basic principles of environmental protection are applied in the field of water management, which are determined by the provisions of the Law on Environmental Protection, which is based on the acquis communautaire, that aim to promote sustainable development and preserve the environment for present and future generations, and are based on the principles of preventive action, elimination of environmental damage at source, shared responsibility, integration of environmental and other sectoral policies, and the "polluter pays" principle.

Water protection is one of the three areas of water management, which includes:

- water waste treatment,
- treatment of solid waste through landfills (leachate treatment),
- water saving measures,
- implementation of legislative measures related to water protection, particularly those relating to the protection of water springs and associated water facilities, and
- planning and reservation with adequate protection of future resources, in particular through regional and urban planning etc.

In modern times, in order to achieve water protection, it is necessary to harmonize implementation of the European directives, and of particular importance are the ***Urban Waste Water Treatment Directive,*** EU Drinking Water Directive, and the EU Directive on the ***protection of groundwater*** against pollution and ***deterioration.*** This is especially important for the town of Bihac, if we bear in mind that Bihać source of drinking water Klokot is affected by the groundwater coming from Croatian territory.
The Summary of European environmental legislation makes over 300 legal - technical documents (directives, regulations and decisions) classified in several groups, but the man is the key solution to this problem if we consider that it was non-educated man who is the major polluter. Thus, the cause of environmental pollution is a man who does not possess sufficient knowledge and feelings in order to preserve the environment in which he lives.

2.1. The Keepers of river Una – UNA EMERALDS

The Association for creating a culture of preservation and protection of the river Una ''Una Emeralds'' was established on 17 May in 1985. Association ''Una Emeralds'' is working on environmental education of children and adults, raising environmental awareness to a higher level, educates the young generations about sustainable development, teaches them the selective disposal of solid waste, reducing emissions, replacing fossil fuels with renewable energy sources, energy saving, preservation and rational use of our natural resources - water and forests, and the study of the basic principles of democracy, as well as mastering the rules of parliamentary decision-making through the Children's ecological Parliament. For its original ecological creativity in working with children, ''Una Emeralds'' were given a series of world recognitions.
Una Emeralds are maintaining a philosophical thought ''*Una River should not be protected from the people, but rather teach people how to protect Una*'', a slogan ''*clear mind - clear Una*'', and motto ''*Una is loved with heart and protected with science*''. The people who live on the banks of the river Una very often have the important thought for the future, which is: ''*Una can buy all the treasures of the world, but all that treasures cannot buy Una*''.

2.2. The problem of solid waste

The biggest problem for the preservation of the environment in the area of the river Una Basin is the problem of solid waste. Unfortunately, we have to conclude that the awareness of young people is much greater than that of the representatives of politics who are not capable to solve the problem of solid waste. While government officials at all levels are spending vast amounts of money to various projects, the municipalities are creating illegal landfills that are potential threat to drinking water in the catchment area of the river Una.
By adjusting the nature to him, a man disturbs the balance of nature, so it's no wonder that many species of plants and animals are extinct, there are no pure river flows, forest landscapes, and the atmosphere every day becomes more and more polluted. Economic and technological development in recent decades endangers the life and health of people in many ways. In order to protect the ecosystems in cities in the catchment area of the River Una it is necessary to solve the problem of solid waste from two or more regional landfills.

During the war in Bosnia and Herzegovina due to war actions, the population was not able to dispose the solid waste in an appropriate manner, so illegal landfills were formed in each town. Unfortunately, these landfills are temporarily kept even today. Each of these landfills has threatened the sources of drinking water. This consequence will remain for the next hundred years, because the toxic substances have deeply penetrated through karst areas. An example is the illegal landfill Gorjevac - Bihać. This illegal landfill is threatening sources of drinking water in the village Ripač, near Bihać.

Table 1: The results of the testing of water parameters

Parameter	**Točak Mevludin**	**Točak Smiljin**	**Stubo**	**Jelina pećina**	**Una**	**Measuring unit**	**MAC For drinking water**
Temperature	12,6	11,0	11,3	10,6	10,9	^{o}C	-
PH	7,56	7,75	7,55	7,51	7,85		6,5 – 9,5
Conductivity	621	752	632	535	437	µS/cm	2500
Oxygen saturation	5,6	6,1	8,1	6,0	9	mg/lO_2	8
(HPK)	9	8	4	5	7	mg/lO_2	3
Ammonium jon- NH_4^+	-	-	-	-	-	mg/l	0,5
Nitrates, NO_3	43,063	37,026	39,257	7,071	2,330	mg/l	50
Nitrites , NO_2^-	-	-	-	**15,821**		mg/l	0,1
Chlorides, Cl^- -	12,127	33,321	17,916	9,569	3,386	mg/l	200
Sulfates	25,995	23,487	15,970	13,281	12,730	mg/l	200
Fluorides	0,289	-	0,061	0,031	0,017	mg/l	1,5
Phosphates	2,750	1,158	2,073	0,997	0,278	mg/l	0,15

The analysis of the results in Table 1 indicate that the water sample in Jelina pećina contains high concentration of nitrite 15.821 mg / l, while in the other samples nitrites were not identified. The values of other parameters, such as nitrates, sulfates and chlorides show a significantly higher concentration than in the river Una but do not exceed the MAC.

Figure 3: Illegal landfill Gorjevac – Bihać

Systematic solution to the environmental protection in the countries members of the European Union started in the early 70s of the last century when the laws and regulations in the field of environmental protection were first enacted. Among other things, this legislation established a system of waste treatment, and established a new branch of industry which we called the economics of waste. Unfortunately, in the territory of Bosanska Krajina this is not yet taken hold in practice. The reason for this situation is a considerable number of people in management positions in the cantons and municipalities that do not have sufficient awareness for the environment protection, so we will have to force them to implement these laws through legislation and standards.
In the catchment area of the river Una there is an increasing amount of waste, as well as the entire territory of Bosnia and Herzegovina. Average production of municipal waste in BiH is amounted to 0.7 to 0.9 kg / per capita per day or 270-300 kg /per capita per year. In the developed countries, the production of solid waste is more than 3 kg / per capita per day. Prior to 1992, industrial companies have been the largest waste disposal units, but due to the devastation of companies during the war, these amounts have changed. However, in the future, the attention must be directed to their re-activation, that is to the treatment of industrial waste.
According to the Constitution of BiH, the Law on Waste Management in Bosnia and Herzegovina, and all the responsibilities which are not explicitly defined as the jurisdiction of BiH, is in the exclusive jurisdiction of the entities. Accordingly, on the basis of constitutional provisions the responsibility for environmental protection is divided into several administrative levels, entities and Brčko District.
According to the Constitution of Bosnia and Herzegovina, human rights and basic freedoms in the category of law, all persons within the territory of Bosnia and Herzegovina are entitled to the human rights and freedoms including the right to live. The Constitution of Bosnia and Herzegovina does not emphasize the right to a healthy

life and a healthy environment through the environment. Therefore, the responsibility for the environment is not subordinated to the state. In Bosnia and Herzegovina, the executive branch of government of Bosnia and Herzegovina is the Council of Ministers, which exercises its rights and responsibilities as a government function, in accordance with the Constitution of Bosnia and Herzegovina, the laws and other regulations of Bosnia and Herzegovina.
Environmental Protection Fund was formed in Bosnia and Herzegovina. Within the Ministry of Foreign Trade and Economic Relations there exists the Division for Natural Resources, Energy and Environment which consists of four departments, including the Department for Environmental Protection. At the cantonal level there are laws on waste management and cantonal waste management plans which are unfortunately not implemented in practice. These plans must be in accordance with the strategy of waste management of the entities. The plan is enacted by the legislative body of the canton.

3. BAS EN ISO 14001:2011

The development and implementation of environmental management system (EMS) according to the requirements of EN ISO 14001/2011 is very important for every organization. The implementation of EMS of the requirements of ISO 14001 organizes training of its customers, employees and the community, demonstrates the ability to consistently and continuously manage aspects of the risk to the environment, reducing their impact on the same to an acceptable minimum or completely eliminating it, giving at the same time the contribution to the development of environmental awareness of its employees as well as a contribution to sustainable development from a position of renewable energy sources. Evaluation and certification of the implemented EMS in relation to the requirements of ISO 14001 is conducted by an accredited certification company, at the choice of the organization.

4. CONCLUSION

Based on the results obtained during this study we can conclude that the education of the population in the area of ecology was successfully and continuously implemented, the outcome of which is a high awareness of the environment preservation which has resulted in water of high quality in the river Una Basin, which can be used for drinking. On the other hand the awareness of the authorities who decide on municipal and industrial waste is at low level. There is a possibility, if no corrective measures to eliminate illegal landfills are taken, the possibility to have drinking water Ripač would be eliminated.

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ERGONOMIC ADAPTATION OF COMPUTER HARDWARE AND SOFTWARE TO VISUALLY IMPAIRED PEOPLE

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Abstract: *Using the computer and computer related technologies does not pose a problem for healthy people, since the computers have been designed to offer maximal efficiency and ergonomic comfort to people without disabilities. On the contrary, computers pose a great challenge for people with disabilities and they could not use them if there was no adaptive technology. On the computers the adaptive technology comes in the form of hardware which is attached to the computer, and then the drivers are installed so that the peripherals can function properly. Within the scope of this work we will explain the current adaptive technologies, problems faced by people with disabilities when using computer equipment, and hardware and software adaptations for the purpose of making computer work easier for visually impaired and blind people. For example, hardware adaptations are devices based on Braille code, modified keyboards, various mouse alternatives and ability switches. While software adaptations are, for example, screen readers, text to speech software, virtual keyboards, speech recognition software and word prediction software. Although modern software and hardware is exceptionally developed, it is still not capable of offering users with certain types of disabilities complete work independence, although recently this has been moving into positive direction.*

Key words*: ergonomic, adaptive technology, hardware, software, visually impaired people*

1. INTRODUCTION

The World Health Organization (WHO), in 1980 gives a classification of impairments (biological), disabilities (functional) and handicaps (social) - (*International Classification of Impairments, Disabilities and Handicaps* – ICIDH) and defines the above mentioned terms.

According to this classification:

- Impairment is any loss or abnormality of psychological, physiological, or anatomical structure or function.
- Disability is any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being.

- Handicap is a disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfilment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual. Handicap de facto represents a difficulty, inhibition that restricts a certain activity.

Invalidity is therefore biological, and handicap a social category; handicap is a social consequence of that which certain disadvantage does to a person in a certain environment. The advent of computers, and later also smartphones, and their integration in everyday life, offers people with disabilities an opportunity to lead normal lives regardless of their sensory and physical impairments, just like healthy people. However, using computers and related digital technologies does not pose a problem for healthy people, while people with disabilities could not use these possibilities without adaptive electronic equipment.

2. COMPUTERS AND VISUALLY IMPAIRED PEOPLE

Computer access for visually impaired people requires one or more means of assistance like speech synthesis, large display, contrast adjustment option (these options are built into modern operating systems) or finally an adaptive system with Braille's code [1].

Person with disabilities wants to access the computer for same reasons as the person without disabilities. However, modifications, and sometimes alternatives to standard hardware and software are often needed and necessary, to enable computer access to these persons. Standard computer system with a keyboard, mouse and monitor can pose a barrier for people with disabilities.

Some of the problems with accessing these peripheral units are:

- Keyboard – standard QWERTY keyboard, used on most computers, is often inaccessible for people with impaired vision.
- Mouse – using a standard mouse with two or three keys can pose a problem for visually impaired people, because successful use of the mouse requires not only good eyesight for tracking the mouse pointer on the screen but also good enough motorical abilities for controlling the mouse. Manipulating with text and graphics with a mouse is a necessary computer skill demanded from all computer users and which requires a lot of exercise before it can be perfected.
- Monitor – computer screen can not be used by blind and visually impaired users without text zooming, change of contrast or text to speech conversion.

3. ADAPTIVE COMPUTER TECHNOLOGIES

Blind persons can not read letters so they need to be converted into a different data form. Technology for visually impaired and blind computer users is very extensive, and the choice of suitable technology depends on various factors. Following is the overview of types of adaptive technologies accessible to visually impaired and blind users.

3.1. Screen reading software

Speech synthesis system consists of a software that when installed on the computer converts text to speech which can be heard through the computer sound system. When the user presses a series of keys on the keyboard, the speech synthesis software converts letters into phonemes – basic language units, which than pass through a series of speech algorithms.

The user can control the speech synthesizer output in several different ways, for example; the amount of produced speech can be adapted, the output can be read letter by letter or line by line. When words and numbers are spoken, synthesiser can be adjusted so it speaks out all the spaces and punctuation marks, and capital letters can be read at another frequency or tone of voice.

One of the popular screen readers for MS Windows is *JAWS* (Job Acquisition with Speech), Figure 1. *JAWS* has sophisticated programmable options which enable the user to convert various video attributes into a spoken output signal. Program can read any screen colour and font type (to instruct the user to change it), it can read web elements form web pages in sequence, so that the user knows on which page he is and what is located on that page, it can define parts of the screen as verbally inactive and so much more. The current version is 14.0 and it supports all the standard Windows versions [2].

Apple's operating systems like Mac OS X and iOS have an inbuilt screen reader called *VoiceOver*, located under *Accessibility Options* and accessible from *Apple menu* > *System Preferences* > *Accessibility*, Figure 2 [3].

Fig. 1. *JAWS – screen reader*

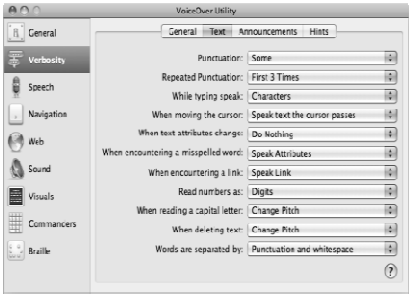
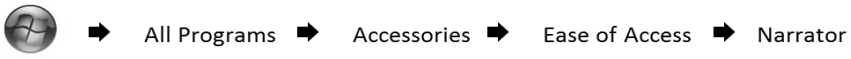


Fig. 2. *VoiceOver interface*

MS Windows in its basic version also has an inbuilt screen reading program called the *Narrator* which can be turned on in the following way:



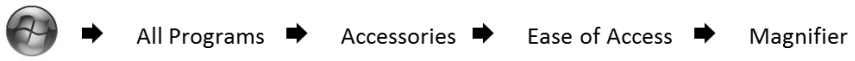
When the program is initiated it reads the moused over content of the screen to the user.

3.2. On screen display magnification

Two basic ways of enabling on screen magnification are installing a hardware based processor which enables this or installing software which will enable magnification of different parts of the screen. Systems for display magnification which are hardware based use a special graphic card, a bigger display screen for displaying enlarged fonts and a mouse or a special joystick for moving the mouse cursor on the screen, while the software based systems enable magnification of letters and graphics without additional hardware.

One additional option for on screen display magnification is on screen colour inversion in a way that letters are displayed in a darker colour on a light background or by changing the contrast of individual colours. Some experts think that this reduces eye strain. Figure 3 shows an example of using the *Magnifier* components in MS Windows.

The magnifier in MS Windows is activated in the following way [4]:



The magnifier is inbuilt into MS Windows and it is used for magnifying the location of the cursor on the screen.

Virtual Magnifying Glass is an open source program which can be used on MS Windows and various Linux distributions, and works on the same principles as the *Magnifier* in MS Windows. Figure 4 shows an example of using *VMG* in a Linux environment [5].

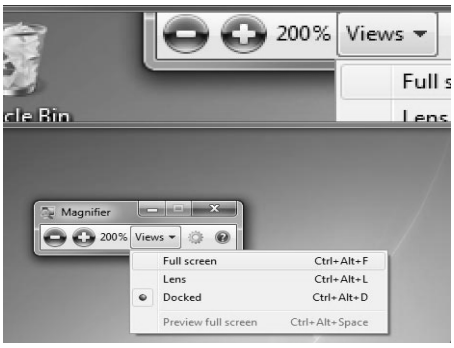


Fig. 3. *Example of screen magnification in MS Windows*

Fig. 4. *Example of screen magnification in a Linux environment*

MAGic Screen Magnification is a popular program for on screen display magnification. Besides the on screen magnification it has a screen reading option. It has 46 zoom levels from 1 to 36 times. Also, their HD text technology brings smooth and sharp letters for all the fonts, even at the highest level of magnification. Figure 5 shows the look of this interface [6].

Apple's operating systems like Mac OS X and iOS have an inbuilt component for on screen magnification called the *Zoom* which can be found under *Accessibility Options.* It can be accessed via *Apple menu -> System Preferences -> Accessibility*. *Zoom* is capable of magnifying the entire screen or parts of the screen to up to 40 times. Thanks to the powerful *Quartz* graphic rendering included in OS X, text, graphics and even video recording can be magnified without any influence on the performance of the system [7].

The external camera system transfers the image in real time and the acquired image is magnified at user demand. The aforementioned enables visually impaired users to watch presentations, diagrams and drawings magnified up to 75 times, with the least ergonomic and physical effort, and if they want they can save the contents for later review. One such camera is *ONYX*, a portable camera with magnification, showed on the figure 6 [8].

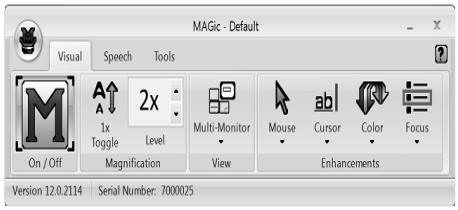


Fig. 5. *MAGic Screen Magnification interface*

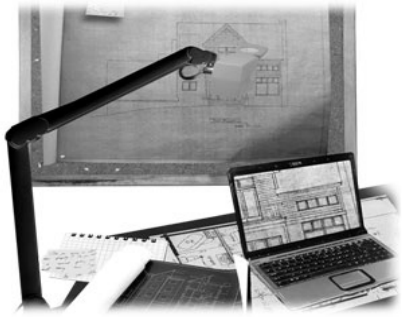


Fig. 6. *ONYX portable camera with magnification and flexible arm*

3.3. Electronic devices based on the Braille's code

Although Braille's code is not used as much as speech synthesis and on screen magnification, many blind users use it to interact with the computer. Systems based on Braille's code are divided into two categories; printers and access devices.

Printers based on Braille code are conceptually identical to normal printers. They are connected to the computer over an USB interface. Software translators and printers enable the users to write high quality documents in Braille code on the computer. Before sending the content to the Braille printer, software transforms the content of the screen to Braile's code.

Access devices based on Braille code are used for controlling the computer. Since the signs in the Braille code consist of a code with six dots, one combination activates one letter. One of these devices is the *BrailleNote Apex 32 BT*. This is a device with its own processor and operating system (*MS Windows CE 6.0*) which can be used by the user to access the computer, and the device can operate independently offering blind and visually impaired users digital communication, data storage, web access, etc. Blind user can use the refreshable screen with 32 cells to "read" books, e-mail, documents, etc. written in Braille code [9].

4. CONCLUSION

In the last ten years there was a significant development of adaptive computer technologies. The future of these technologies is great and they will only continue to develop. Development will depend on factors like the appearance of new technologies, new methods of learning and artificial intelligence (that will assist the disabled person).

Moreover, this technology is going in the direction of thought controlled computers. However, all this is in the early stages of development and years will past before it commercially appears on the market.

Computers have also developed at tremendous speeds, enabling faster and faster data processing not only for people without disabilities, but also for people with disabilities so they can better adapt their computers to their own personal needs.

Computer equipment has also seen numerous changes and upgrades. Devices are smaller and enable easier installation, and thereby easier use. Software is much more stabile and powerful, especially speech recognition software and text to speech software.

From all this we could get an impression that there are no real obstacles for people with disabilities. Unfortunately this is not so. Still, there are real challenges facing computer users with disabilities. These challenges are user interfaces that still can not completely communicate with blind and visually impaired people and exceptionally expensive solutions for people with physical disabilities which do not exactly function in a way that would suit these users.

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3D BUILDING DESIGN

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Abstract:

Three – dimensional (3D) modeling has a wide application in various fields of technology and science today. With 3D modeling it is possible to create a simple and complex objects that can be later rendered or animate. Thanks to the modern tools that follow the development of 3D technology, a high quality modeling product can be achieved. This paper presents the design of simple residential building through the stages of 3D modeling, rendering and animation in software Blender.

Keywords: *3D modeling, rendering, animation, Blender*

1. INTRODUCTION

3D modeling is the process of developing a mathematical representation of any three – dimensional object via specialized software. The result of 3D modeling is a 3D model that can be shown as a two – dimensional image or can be used in computer animation. Models are useful in various phases of design of the products or systems because they allow analysis of the products or systems and to better percieve their physical nature.

Computer animation is the art of creating moving images using a computer. It is a subcategory of computer graphics. Sometimes the result of animation is displayed on the computer screen, but sometimes as a result is used other media. In order to create an illusion of movement, an image is displayed on a computer screen and then quickly replaced by a new image that is similar to previous but slightly shifted.

Rendering is the process of creating the final 2D image or animation from the prepared scene or 3D object. Before rendering objects must be placed within 3D scene. It is necessary to determinate the spatial relationship between objects in a scene including location and size.

3D models are created using 3D modeling software. *Blender* is a rendering/animation/game development open-sourced freeware program maintained by the Blender Foundation.

2. 3D MODELING

Basic shapes from which begins the process of modeling are primitives. Mesh types (Primitives) in Blender are: Plane, Cube, Circle, UV Sphere, Icosphere, Tube, Cone, Grid, Monkey and Torus. Meshes can be changed by selecting the verticies or their moving, scaling or rotating. A more refined method of altering a shape is by extrusion. The selected verticies are duplicated and placed into grab mode ready to be moved [1].

There are other forms of editing options such as: joining and separating meshes, deleting verticies/ edges/ faces and adding faces. Using a few basic shapes is designed a house model (Figure 1).

Figure 1: House model

Mesh objects can have their shape modified by using Blenders Modifiers. There are a four groups of modifiers: Modify, Generate, Deform and Simulate [2]. A modifier may be selected from the group to change the shape of an object.

In the 3D virtual world the most important thing is to provide effective editing of objects. There are a several ways of editing such as: Object Mode, Edit Mode, Sculpt Mode, Texture Paint, Vertex Paint and Weight Paint. However, the two most important methods are [2]:

- Object Mode and
- Edit Mode.

Edit Mode is intended for modifying the shape of the object by selecting verticies on the object. In this mode three things are important: Vertex, Edge and Face. Verticies are the joining points of the mesh. By default in Edit mode, Blender selects verticies. Edges are the lines that connect two verticies which faces surfaces that connect the edges.
Object mode affects the objects as a whole.

2.1. Materials and textures

What is a material? A material is a color but it is much more than just a color. It could be any shade of color; the color can be shiny or dull or it could be transparent or it could gradually fade from one shade to another. The possibilities are endless. The material panel is used to change some of the physical properties of the object in the way it looks. This is a place where you set the object`s color and other properties such as: Shading, Transparency, Glossy or Flat, Reflective, Halo Effect [1]...
After adding a material, textures are added to object. Textures are physical characteristics of a surface like bricks, carpet, woodgrain, etc. Blender comes with a series of built in Textures from which to chose or you can use any photo image stored on your computer [1]. Anything that can be saved as a JPEG image can be used as a texture in Blender. Most other image type files can be used as well (png, targa, TIFF, bmp). Blender can also place movies on a surface and you can animate the textures. Figure 2 shows a house model with added materials and textures.

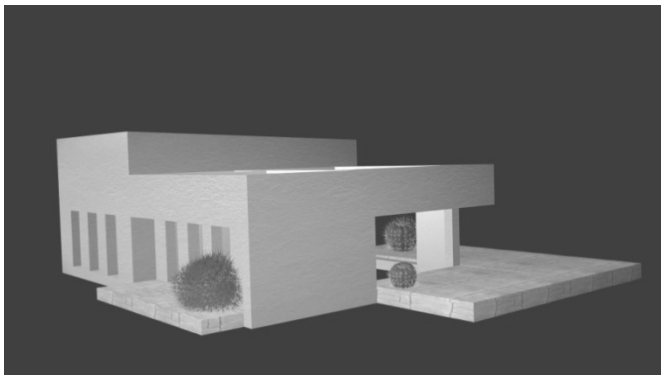

Figure 2: House model with materials and textures

2.2. World Settings

The World Settings allow to set background for scene [1]. The default World setup is the dull grey which displays when an image is rendered (Figure 2). The background in the render is not the same as the background in the 3D window. Blenders inbuilt Textures can be used to create a background. Also you can use any image stored on your computer as a background. The easiest way to create clouds is to use a texture in a world settings (Figure 3).

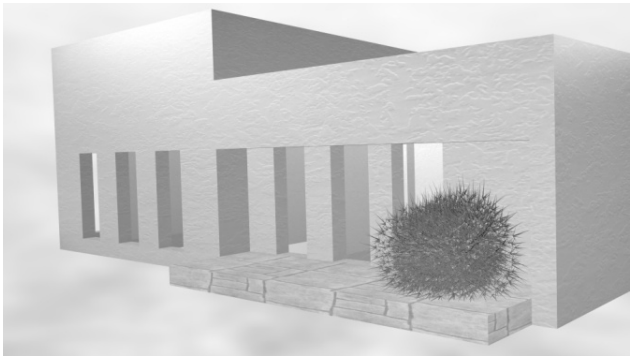

Figure 3: House model with background

3. ANIMATION

Animation in Blender is the process of creating the allusion of movement or change of state. The movement or change of state may be that of a single object or the entire scene. This is accomplished by creating a series of still images each one slightly different to the next which when displayed one after the other in quick succesion create the allusion. Each still image is a single frame of the animation. Each frame is rendered and turned into digital image. This is usually into a JPEG format. Finally all the images are compiled into one movie film. Movie quality control materials, textures, lighting and cameras including frames per second, output size, file type and compression. The render format determines how many Frames Per Second the animation should run at [2]:

- NTSC (US 30 fps),
- PAL (Europe 25 fps),
- Film (24 fps).

Moving, rotating and scaling are the three basics modifiers to use in an object animation. In most animation programs camera can follow the path or object (or both) while moving [3]. This option saves time of animation and the number of frames.

3. RENDERING

A rendering is a pictorial output of a 3D scene or object. Features like materials, lighting, oversampling and shadows control the effects and quality of rendering. There are two tools for rendering: Blender render and Cycles render. Cycles render can render scene with many polygons and Blender render is faster for simple applications where physical accuracy is not important [5]. However, richness of visual experiance determines lighting scene. There are many models of light, so we can talk about a model with three types of lights as the basic model and more complex models with more lighting. Rendering of the house from the front and left side is shown on Figure 4. Scene is illuminated with three types of lights.

a) b)

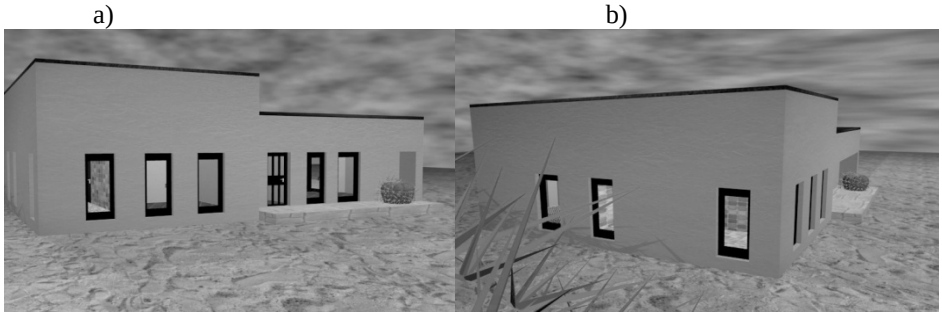

Figure 4: Rendering house
a) from the front side; b) from left side

Figure 4 shows a house model under natural lighting. Below is a right side view of the same model but under artificial and natural lighting (Figure 5).

a) b)

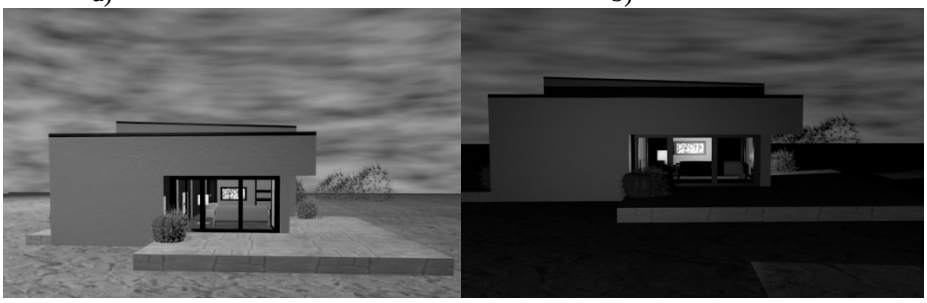

Figure 5: Right side of the house model
a) under natural lighting; b) under artificial lighting

Figure 6 shows back side of the house where you can see the shadow that caused the sun lamp.

Figure 6: Back side of the house

5. CONCLUSION

Programs for 3D modeling are applied in industrial design, science, for the media, as well as for visualization of the design. Blender 3D is wonderful application, especially at the price. 3D building design in Blender revealed many features of this program. In this program simple and complex objects can be efficiently modeled. Blender`s features include 3D modeling, texturing, animation, camera tracking, rendering, video editing and compositing. Parts of the projects from other programs can be inserted in Blender.

Abilities of the software are evolving and building rapidly. Representation of 3D building design has been made to version 2.66 which is characterized by improved rendering, dynamic sculpturing, work with transparent images and textures. Upon completion of the design was released version 2.67.

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DESIGN OF INFRARED RADIATION PROTECTIVE VEST

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Abstract

Infrared radiation is electromagnetic radiation with wavelength larger than the wavelength of visible red light, and smaller than the wavelength of radio waves. These waves are emitted by hot bodies when they are in an excited state, absorbed by most substances whereby the energy of infrared radiation converted into internal energy, resulting the increase of temperature. The aim of research is designing a vest and testing of materials that would be used for protection against infrared radiation. Measurements were made on the thermal mannequin George©. Design solution of vest is displayed by a computer program C - Fashion Design (R) V4.0. The vest is designed for workers in construction and agriculture, and to all those who are exposed to direct infrared radiation.

1. INTRODUCTION

Wearing protective clothing with the protective characteristics and satisfactory level of comfort is of great importance to people who perform activities related to the physical work in the open, exposed to high temperature differences - from heat to cold. For the purpose of designing protective clothes with satisfactory level of comfort it is necessary an appropriate assessment of the environmental impact on the exchange of heat between the body and the man, which in turn involves knowledge of heat transfer through clothing. Clothing is a barrier between the human body and its environment and its functional role of keeping the body in an acceptable condition in different temperature conditions. Factors that effect on heat transfer are numerous: clothing design, level of adhesion from clothes to body, layering, surface of garment covering the body etc. Human reactions to heat or cold depends on the individual who is exposed to environmental conditions, clothing worn by the individual and the nature of the work being performed. This paper investigated the change of heat in the human body influenced by infrared radiation, by testing of textile materials on thermal mannequin. Testing was performed by simulating operating conditions on the people who are exposed to high temperatures on their line of work. For these environmental conditions we suggested some design solutions for upper garment vest.

2. RESEARCH PROBLEM

The study consists of two parts:

- Resistance test of different textile materials on the infrared radiation on inflatable thermal mannequin
- Design of vest for protection against infrared radiation

Considering that the head and the shoulders are most exposed to sunlight, tested samples of textile materials are usually used for the coverage of those body parts. Besides the classic fabrics, web manufactured on electrospinning device from polyurethane nano/micro fiber were used in research. Textile fabrics have been tested using high temperature to simulate infrared radiation on the inflatable thermal mannequin. Testing was performed on each material separately with the addition of substrate (tulle) of equally spaced rubber rings which allow free circulation of air between the material and body of thermal mannequin that reduces the temperature of the 'body', as previously defined. Software program C-Design Fashion (V4.0) for designing the infrared radiation protective vest was used.

3. METHODOLOGY

The work plan consists of two steps:

- Testing of heat retention through textile materials on the thermal mannequin - George ©, with infrared radiation, and
- Designing the vests for physical activity in the open - design vests using the computer software C - Fashion Design (R) V4.0.

Materials and methods

Materials tested in this study designated as T1 do T6 were different (Table 1). The temperature was measured using infrared camera FTIR. (T1 – T6).

Table 1. Tested materials

Sample designation	T1	T2	T3	T4	T5	T6
Materials	Woolen fabrics	Woolen fabric	Polyester fabric (PET)	Polyester fabric (PET)	Mercerized cotton fabric	Polyurethane web fabric

The sample designated as T6 from Polyurethane is prepared by Electrospinning device model NT-ESS-300 with the following process parameters:

Distance between the tip of the needle and the collector of fibers: 18 cm
Electric voltage: 20 kV
Flow velocity of polymer stream: 4ml/h
Speed of horizontal motions of collectors fibers: 0.205 rpm
Rotation speed: 36 r/min.

The prepared polymer solution of 12% polyurethane, dissolved in solvents organics DMF (N,N dimethyltetraflouride) and THF (tetrahydrofuran), a ratio of 1:1, influenced by an electric field pushing out the volume out of the syringe of 16 ml. Four ml of polymer solution has been spun in one hour. After an electrospinning micro/nano fiber textile fabric (web) is dried for 24 h to allow the evaporation remaining solvents. An electrospinning of polyurethane is done on tulle for easy removing from the roller.

Setting up the rings

Each textile material was examined with and without background made of tulle on which were placed 24 rubber rings, Figure 2. Rubber rings are part of the bottom of the substrate, and they facing the body models, while along tulle are placed tested textile fabrics. Tulle fabric has no impact on the change of temperature, which is confirmed by measurements. The purpose of the rings is to create space between the body of the mannequin and tested material in which air flows freely and reduces the heat retained in the body of mannequin.

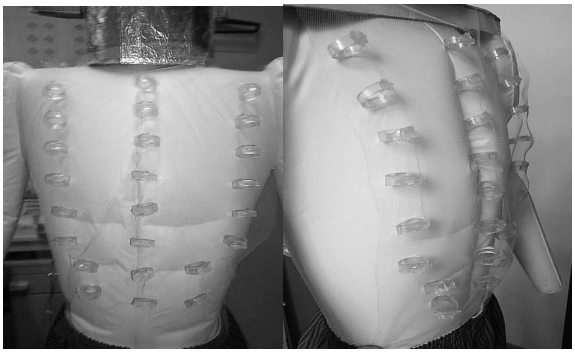

Figure 2. Rings attached to the tulle on the tested body surface area of thermal mannequin

Testing method on thermal mannequin George ©

Selected textile materials were examined in order to assess heat retention in case of infrared radiation, based on changes in body temperature of thermal mannequin George ©, with minor modification of the system, according to Figure 3.

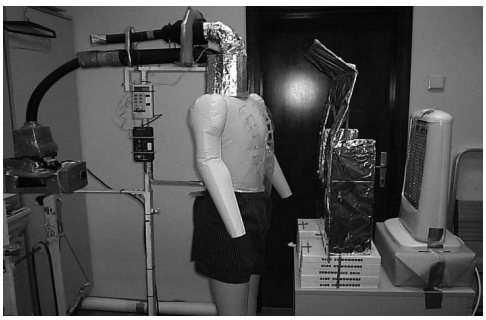

Figure 3. Inflatable thermal mannequin George©

Source of infrared radiation with the intensity of 400 W was used on the inflatable thermal mannequin from a distance of 55 cm from body model. The aluminum construction had the role of protecting the model body parts that were not covered with tested textile material (arms and shoulders). As previously established, the source of infrared radiation must be focused directly on the test material in order to precisely determine the protective effect of the material. For this purpose, only a part of the chest dimensions (30x50 cm) was exposed to radiation.

The materials are placed on the mannequin and tested when the model and infrared lamp involved in the work. During the test environmental conditions were monitored, the ambient air temperature was maintained at 22 ± 1 °C because the relative humidity depends on it. Before the beginning, examinations were performed on the undressed thermal mannequin. Power is controlled by a variable transformer and maintained at a constant level during all experiments. Thermal model is heated approximately from 100 to 120 watts of power, in order to keep mannequin input temperature at 42 ± 0.1 ° C. Output air temperature is measured when the system reaches a balance (after 10 minutes). Initial output temperature is entered at the moment of setting down the tested material on the mannequin and the final output temperature after 11 minutes of heating with infrared lamp.

4. RESULTS AND DISCUSSION

From the results obtained given in the Table 1 (T_{out1}) it can be read that there was a reduction in body temperature mannequin in almost all materials by using the rings Rings give the possibility of air circulation so that for most of materials measurement had better results that is the outer temperatures decreases. Fabric made from Polyurethane (designated as T6) is only effective when it is combined with rings, without them mannequin gives worse results than other materials.
With woolen fabric (designated as T1) after IR exposure temperature increases from 32.7 °C to 33 °C while in the same material with rings, temperature slightly decreases from 32.9 °C to 32.7 °C. Woolen fabric designated as T2 after IR exposure also has better results when the material is combined with rings, that is indicated in decrease of temperature from 32.8 °C to 32.4 °C. Polyester fabrics designated as T3 shows reducing the temperature with rings after IR exposure from 33.1 °C on 32.6 °C. Polyester fabric designated as T4 without rings after IR exposure has the temperature increase by 0.5 °C while with the ring temperature decreases by 0.3 °C. The best result are obtained with

mercerized cotton fabric designated as T5 after IR exposure with and without rings where there were decrease in temperature from 32.7 °C to 31.1 °C.
The investigations made in this research work are preliminary with the aim to get the levels of the changing the protection of different kind of fabrics that are exposure to IR radiation and will be continued.

Table 2. Results of testing

Time [min]	Materials	IR	T_{INP} [^{O}C]	T_{OUT1} [^{O}C]	T_{OUT2} [^{O}C]	Q [W]
13:44	MW	NO	42	22	30,8	159,38
13:55	MW	YES	42	30,8	33	128,08
14:06	T1	YES	42	32,7	33	128,08
14:17	T1+R	YES	42,1	32,9	32,7	133,77
14:28	T2	YES	42,1	32,6	32,9	130,92
14:39	T2+R	YES	42,1	32,8	32,4	138,04
14:50	T3	YES	42	32,4	32,2	139,46
15:01	T3+R	YES	41,9	33,1	32,6	132,35
15:12	T4	YES	42	32,7	33,3	123,81
15:23	T4+R	YES	42	33,1	32,8	130,92
15:34	T5	YES	42	32,7	31,1	155,12
15:45	T5+R	YES	42	33	33,1	126,65
15:56	T6	YES	42	33	33	128,08
16:08	T6+R	YES	42	33	32,6	133,77

Legend for Table:

Time [min] - Time of measurement
Materials - Tested materials
IR - Infrared radiation
T_{INP} [^{O}C] - Input temperature of mannequin
T_{OUT1} [^{O}C] - Output temperature of mannequin
T_{OUT2} [^{O}C] - Output temperature of mannequin (after ten minutes of testing)
Q [W] - Obtained retained heat
MW - Mannequin without clothes
T_1 - T6 - Tested textile materials
T_1+R - T6+R - Tested textile materials + Rings

Heat Q was determined using the following equation:

$$Q = \rho V Cp (T_{INP} - T_{OUT2}) 1000 \quad (1)$$

where are: ρ - air density (1,18 kg/m^3), V - volume of airflow (0,012 m^3/sec) as well as Csp - specific heat of air (1,005 KJ/(kgK)).

Design solutions of infrared radiation protective vest

Design of infrared radiation protective vests was made using the computer program C - Fashion Design (R) V4.0 which is used for designing the garments. Design of a vest for

protection from infrared radiation is shown on the front and back side and from the side (Figure 4). The special design with layers of materials (breathable layers) allows air circulation, cooling and decreasing the body temperature a person who wears a vest.

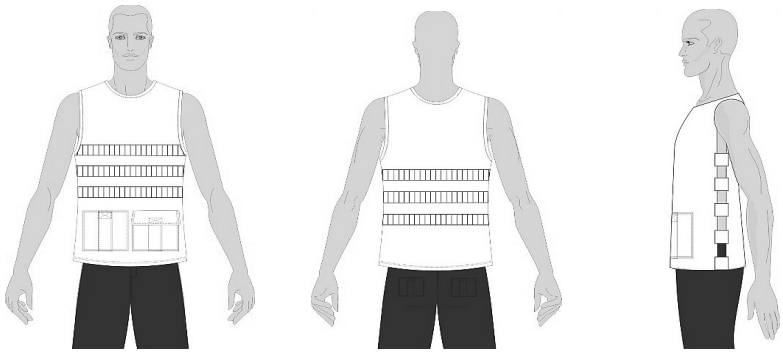

Figure 4. Conceptual design of protective vest of mannequin shown at the front, back side and from the side

5. CONCLUSIONS

Chosen materials for testing-scarves (woven and knitted fabrics as well as nonwoven fabric) that are worn in situations where a person is exposed to infrared radiation are used to test on mannequin. Using the process of electrospinning it has been produced the non-woven fabric composed of nano/micro fibers from Polyurethane, for comparison purposes with the standard (classic fabrics). Testing the heat retention of textile materials was carried out on the inflatable thermal mannequin - George © with infrared radiation using infrared lamps under controlled conditions. The rings are placed on tulle. Results have shown that most of the materials measured with rings give the possibility of air circulation and ensure the decreasing of temperature in the mannequin. Fabrics made from polyester fibres ensure greater protection than woolen fabrics with and without rings. Mercerized cotton fabrics give the best results without the rings. Polyester fabric also provides good protection from infrared radiation, but only in combination with rings. It is given a solution of infrared radiation protective vests, in a way that ensures breathability during exposure to high temperatures. It is achieved by using a special stacking of materials in some places of infrared radiation protective vests. The vest can provide protection against infrared radiation for agricultural workers and workers in construction who are exposed to a high level of solar radiation.

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SOPHISTICATED ANTI BEDSORE MATTRESS

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Abstract
This paper describes a new sophisticated solution for anti bedsore mattress, as a result technological project financed by the Croatian Institute of Technology (HIT). In the paper was presented emerge of bedsore ulcers, causes of the occurrence and impact of beds and matters, as well as the impact of external factors on the occurrence of pressure ulcers. The new elements of the developed solution, as well as operating system are described. Also, the advantages of the new solution over the existing market are shown.

Keywords: *bedsore, anti bedsore mattress, prevention of pressure ulcers, health care*

1. INTRODUCTION

Sophisticated anti bedsore mattress is the product (Technology project Croatian Institute of Technology, and the beneficiary is the Faculty of Textile Technology in Zagreb), which was developed with the aim to prevent pressure ulcers (Latin decumbere = lie) in patients with long-term must lie. Also, as part of the first goal, to eliminate the pain in locale sensitive areas of the body due to the pressure of the body, regardless of the cause of the pain (wounds, burns, charges, etc.). Past experience has shown that the pressure ulcer complications arise due to prolonged hospitalization, and often occurs in people who have experienced severe trauma or disease, which is why they are forced to stay on longer treatment [1].
Bedsores sores (ulcers) caused a greater and prolonged pressure on the skin which stops blood supply. Therefore tissue cells dye, develop bacteria and infectious inflammation, wounds. Bedsore ulcers occur on the external parts of the body (Figure 1), mainly in places and parts that are most exposed to the pressure of the body weight to the ground on which the body rests, and it is an important factor that contributes to the hypoesthesia or anesthesia, ie, decreased sensitivity or insensitivity of body. Maximum pressure of the tissue is always in the bone protruding parts, such as sitting bones, hips, elbows and heels, and the areas where fat is less developed. A healthy person during sleep or prolonged lying automatically changes the position and thus allowing the blood flow to the potential areas of pressure ulcers. If for any reason stops moving, the blood supply will be interrupted, and thus weakens the flow of oxygen, and results in pressure ulcers. Mattress pressure (beds) is the largest on the bone, so the most damage will be there. The skin sores may be tiny, but under the skin can be extensive damage [1, 5].
Pressures on the surface that is greater than 32 mmHg stop blood flow in the peripheral blood vessels and cause ischemia, but within two hours. After 10 hours, there is a

radical necrosis. Average pressures in some places in various positions are shown in Figure 1 [2, 3].

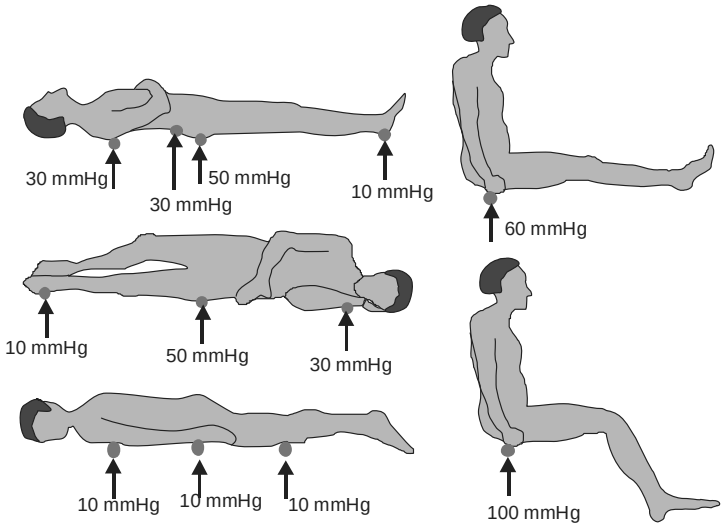

Figure 1. Potential sites which produce bedsores ulcers and average load in some places in various positions

Acute phase will not necessarily turn into a chronic, i.e., the emergence of classical compressive ulcers, if the pressure and other etiologic factors are removed. The images of bedsore ulcers in an advanced stage and required surgical intervention for their rehabilitation are showing in Figure 2 [1, 2]

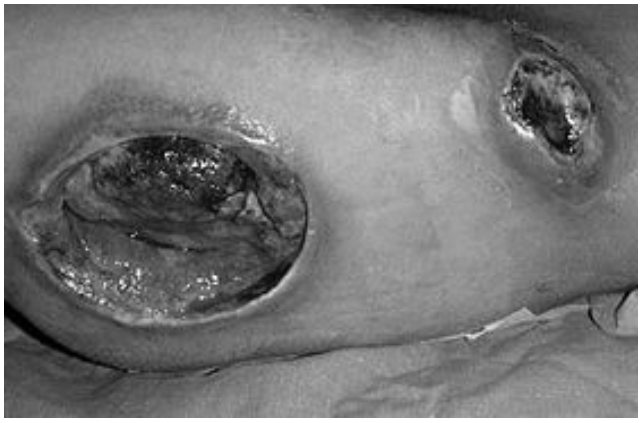

Figure 2. Bedsore ulceri [9]

When examining the etiological factors they can be external (exogenous) and internal (endogenous). External factors are: long lying on the hard and uncomfortable bed, wrinkled linen and personal laundry, moisture in the bed, improperly set of immobilization funds, joint contractures, and muscle spasticity at the predilection sites,

permanent catheters or trahenalne cannels. Internal factors are: chronic and terminal diseases, diabetes mellitus with resulting peripheral, angiopatic changes, malnutrition, hypoproteinemia and anemia. [1]

2. EXISTING SOLUTIONS

Existing solutions of bedsore beds manufacturer used passive, active or combined operation. Under the passive activity are considered derived projections on bed on which lies the body, and blood flow that is stopped by projections compensated on the places where there is no pressure of surfaces, i.e. hollows.
The substrate must be high quality in terms of softness and comfort, must prevent leakage of fluid and thereby the possibility of leakage of air and gases.
Many anti bedsore mattresses with passive character have bumps (blisters) with compressed air on which the patient lies or sits, figure 3. It is believed that in this way two effects are achieved: a) air is compressed or retained in all chambers of the same level of pressure (as the connecting vessels), and also establishes soft pressure on the patient's body, and b) alternately set projections allow the blood vessels to supply blood to the tissue near the place of contact [5, 7].

Figure 3. Passive anti bedsore a) mattresses, and b) the seat-
Orthopedics International [9]

Often advertised as anti bedsore beds mattresses (passive activity) of the material Tempura (high-elastic material with an "open cell" developed by NASA), or sheets of material Orgahexa woven of carbonized cellulose fibers certain types of oak, which was developed in Japan.
By active function of mattress it alternately changes the pressure on the body and provides massage, thereby preventing stopping blood flow and ischemia.
The most sophisticated anti bedsore mattresses available on the market have: a) adjustment of the air pressure which size is selected according to the weight of the patient, b) a type of massage, c) repeating of massage after exactly fixed time, d) test of set pressure e) management of these options of the mattress, f) signaling (sound) when the pressure drops.
On the market, there is a number of solutions available from different manufacturers, some of them are shown in Figure 5

a) b)

Figure 5. Air mattress with a compressor) Proderma 2, b) Proderma 1 [8]

There is a large number of very similar solutions available on the market, either as separate anti bedsore mattresses or mattresses placed on the same bed as anti bedsore bed. The only deviation from this is anti bedsore bed so called Stryker's bed, which is based on the need for changes in patient load to the substrate tilting beds in all directions and thus changing the power load on the basis of the same body parts. Management is usually done by remote control by the medical staff.

3. NEW SOLUTION

From the foregoing it is evident that all existing solutions of anti bedsore mattress are based on an air chamber that can inflate or deflate by the will of the patient, medical staff or certain automatic programming device. A new approach to solving anti bedsore mattress can be expressed as follows:

A. Passive impact on the prevention of pressure ulcers

1. Anti bedsore mattress due to embedded bladder accomplishes, the effect of partial pressure on the patient's body, in order to provide continuous blood circulation in the subcutaneous area of the body.
2. The bladder can inflate in different sizes so the pressure lying comfort, as well as the intensity of the projections can be changed.
3. Anti bedsore mattress area is like the area of usual mattresses for beds, unlike other anti bedsore beds derived from rubberized fabric or plastic, and are conducive to sweating and wetting the surface as one of the factors of pressure ulcers.

B. Active impact on the prevention of pressure ulcers

Unlike other anti bedsore mattresses that are offered on the market, the active influence of ABP is significantly richer and more sophisticated. There are the following possibilities for active action of anti bedsore mattress:

1. Monitoring the loads of the patient's body
    a) Visual – different color intensity on the computer screen
    b) Numeric - the amount of load F (x, y) at a selected position labeled substrate shows on computer screen.
2. Set of selected pressure levels in bladders
    a) Setting initial parameters, pressure Pp, time Tp and p(x) pressures matrix.

b) Pressure is visually shown.

3. Decrease of pressure in rows that are overloaded

a) Visual display (columns) - it is evident which rows are under the pressure, and which not.

b) Numerical display - shows the pressure values in each row.

4. Setting of uniform surface pressure in bladders

a). At the same time, the bladders are filled under load and thus a uniform load surface is achieved by using the appropriate program.

b) Placement of pressure to the desired value p(x) for each row, by activating the appropriate program. In this way is formed matrix of given pressures which are automatically recorded to disk,.

5. Six types of massages, which are achieved by certain rhythms of inflating and deflating the bladder. Massage can be repeated by selecting the length of the pause between the two types of massage.

Additional features of the new anti bedsore beds

- Management and visual surveillance can be carried out remotely, from the workplace for e.g. from room of medical staff or doctor.
- - One portable computer can operated more anti bedsore beds.
- - Anti bedsore mattress is mounted on a hospital bed with the possibility of raising and lowering the bed.

C. Structural solution

The initial idea and the technical solution that is the basic of anti bedsore mattress is a consensual patent "Intelligent sick background" PK20041063 (authors: G. Nikolic, D-Rogale) from 2004. Later, in year 2012, the design of bladdesr is protected by as the basic element antidecubital substrate EU Certificate No. DM/078696 (authors: G. Nikolic, D. Rogale).

Key elements are bladders, and at same are embedded with force sensors, Figure 6b. The whole 595 bladders are fed with compressed air whose pressure can change with the proportional pneumatic valve. Each row of the bladder can be supplied with the size of the pressure which is determined by the program. Bladders are arranged beneath the thick cover, Figure 6a, and placed on elastic strips.

a) b)

Figure 6 Bladders a) bladders on the mattress under the covers, b) bladder with force sensor

Based on the data of pressure sensors visually and numerically is displayed the size of mattress load, Figure 7. Under the mattress is attached a pneumatic system that supplies bladders with compressed air. Mattress with bladders, cover and pneumatic system are located in a hospital bed, Figure 8.

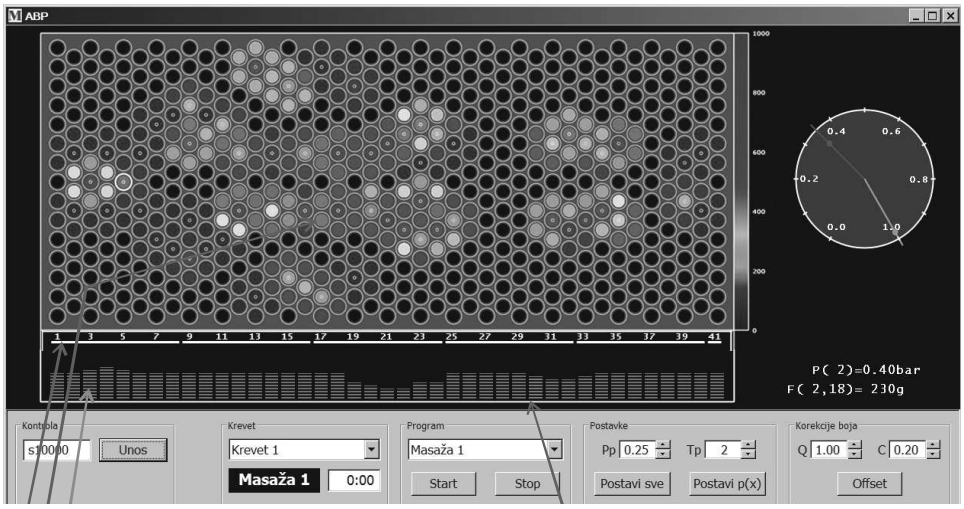

Figure 7 A laptop screen

Figure 8 A anti bedsore mattress,

4. TESTS AND CONCLUSION

The massage effect on the blood circulation is well known but it was necessary to examine how this effect is realized this new anti bedsore mattress, It can be achieved in two ways:

a) the measurement of the so-called oxygenation.

b) measuring the perfusion of loaded parts of the skin.

For tests are selected older subjects (> 65 yr.) with poor circulation. To measure the oxygenation was used is Oximeter PalmSAT 2500. After two hours of lying the massage was turn on and the results showed a noticeable increase in oxygenation, as a result of subcutaneous tissue perfusion. Increase of 2% is significant and sharply defined.
For the purpose of temperature measurement is developed and manufactured a new electronic device that has eight sensors and monitors absolute and relative temperature. Time/temperature diagram of each sensor is stored. Temperature sensors are shown in Figure 9.

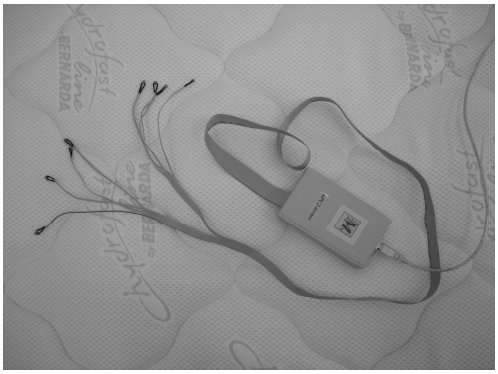

Figure 9 Sensitive temperature sensors

Temperature sensors were placed in: blades, lumbago, buttock and legs. The temperature drops after two hours of lying down (without massage) only at the leg. This phenomenon can be explained by the lower blood flow to the extremities. After the temperature drop of for about 6^0 there was a sudden rise in temperature immediately after the inclusion of massage.

Anti bedsore bed (mattress mounted on a hospital bed were examined approximately one month by a orthopedic specialist in his office, and by medical staff in hospital who expressed satisfaction with the capabilities and efficiency anti bedsore beds. The research is to be continued.

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FOOT BAROPODOMETRY REGARDING ON BODY WEIGHT

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Abstract:

While standing, we used baropodomerty to measure pressure on foot area.Human foot cause force reaction while making contact with the base. We also used plantogram and a special foam to measure foot size pressure and force as well as pressure and force that is appearing between the foot and the surface. In this work, we compared pressure between normal and deformed men and female foot against their body weight. With this analysis, we found that deformed foot makes bigger pressure on heel spur. In this research, we had 10 male and 10 female candidates. We were measuring weight, height and foot area as well as pressure and force that foot produce while walking. At the end, we concluded that the candidates with bigger body weight, made more pressure and force on their feet. We are hoping that this research will contribute in shoe factory to decrease weight on feet.

***Key words**: Baropodometry, biomechanics, foot physiology*

1. INTRODUCTION

Feet has 26 bones,33 links and about 100 muscles,ligaments (connects bones with other bones) and tendons (connects muscles with bones) along with blood veins and nerve supply.Foot root, asso tarsi, is made out of 7 bones that takes load of lower leg. [1] Big part in walking has feet dome and foothold that transfer mechanic force to the surface. While we stand, our body weight is transfered through the middle of our lower leg and down to the foot ankle. Forces that occured, go into two dirrections. One goes into the tarsal bone, and the other one goes to the tip of the toes. [5]

The foot statics is different if the body weight is not balanced, so that is the reason of many deformed feet (Figure 1 and Figure 2.) [3].

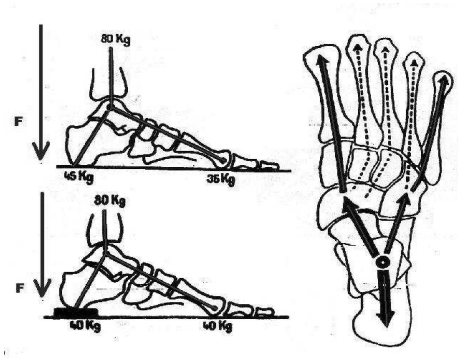

Figure 1: Schedule force of body weight

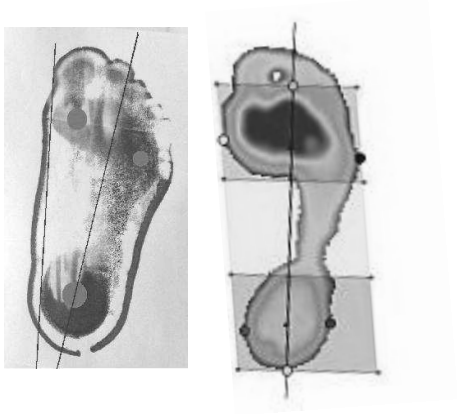

Figure 2: Showing footholds with (a) scanner and (b) plantograf

Upper and lower foot joint, has big meaning in mechanical function of the feet, and like that, they make complex unit that works like anatomic, functional and clinical unit. Statical foot function depends on feet bones, ligaments and lower leg and feet muscles. [2], [4]

2. METHODS AND MATERIALS

The candidates were 10 male and 10 females with different kind of feet (age 22 – 75, height 160cm – 191cm, weight 60kg – 130kg). For the research, we used tape measure that is common in shoe manufacture, plantogram and special foam, Figure 3.

Figure 3: Example of using foam for taking foot prints

We took the foot print from the candidates by steping into the foam, and after that on the plantogram. The weight and height was recorded also. Measuring lenght and width, we got foot area from each person. Foot pressure against the surface was calculated after that. Complexity of calculating foot area is based on anthropometry measures and there are lots of measures in shoe manufactory that are mutually related, but every has their own flaws and advantages. International standard for size and labelling ISO/TC 137was brought by international chamber for shoe quality ISO 9407:1991. Croatian anthropometry system harmonized body weight measures with this standard. With making the shoe size system, they want to achieve that international standard will be the

only one in measuring the foot, which is the base of the shoe size. That measuring system is based on 2 measures, lenght and width of the foot. Girth of the foot and other measurements are used in different phases of the foot researches. Foot lenght is horizontal distance between the most prominent toe and the back of the heel, measured in standing position so that the body weight would be evenly distributed on the horizontal surface. [7] [8]

3. EKSPERIMENTAL PART

To use a plantograf device, you have to smear an ink all over the rubbery obverse of the device. Under the obverse is a paper for shoe print, and on the top is the foot. The rule is to stand upright, with body weight evenly distributed on both feet, and by stepping on the area, we get the print on the paper, Figure 4.(a,b,c,d).

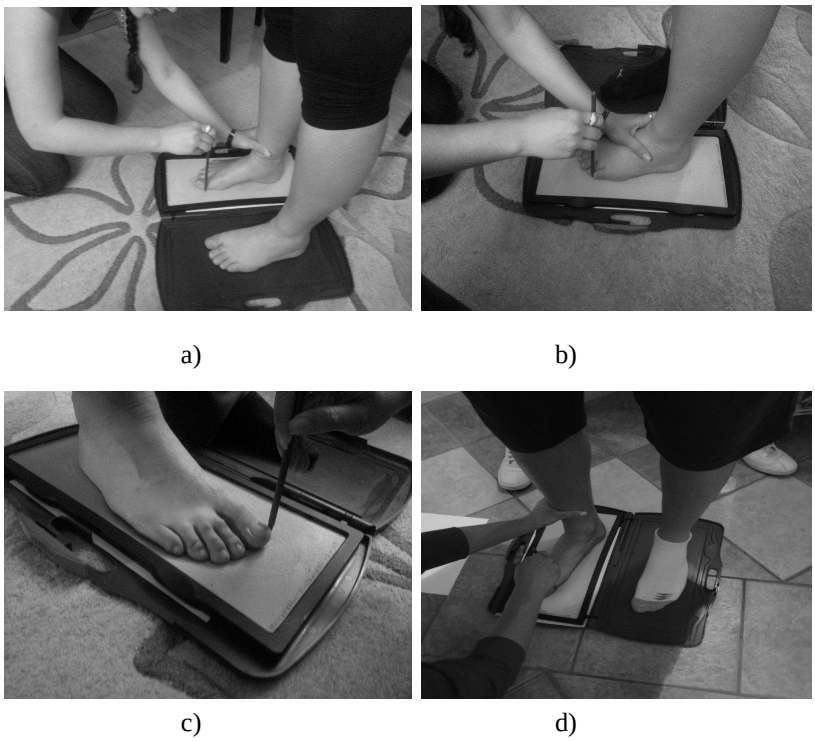

Figure 4: Measuring feer with plantograf

After that we use plastic pen to mark the edges of the foot. By transfering dynamically body weight, brace from one leg to another, we get the balance. People with deformed feet are big scientific, economical and social problem in community and to measure force on the foot, different kind of optical and electronic devices are used, Figure 5. and Figure 6.

Figure 5: Display range toes and foot length, **Figure 6:** Footprints and shoe meter

In this research, we used plantogram and foam which is great, because you can get negative foot prints. Getting the foot measures, we got realistic foot length from the prominent toe till the back of the heel and the width at the toe bend. With normal foot in upright position, the body weight stretches from toes, over the metatarsal bones and middle part of the foot, back to the heel. At the deformed foot, all the weight is based on the metatarsal bones and middle part of the foot, which brings deformations and not be able to walk. We examined the foothold and decide that people with bigger weight produce higher foot pressure, bigger force on the surface no matter male or female.

4. RESULTS

Figure 1 shows the measurements data of height, weight, foot area, pressure and force for means.

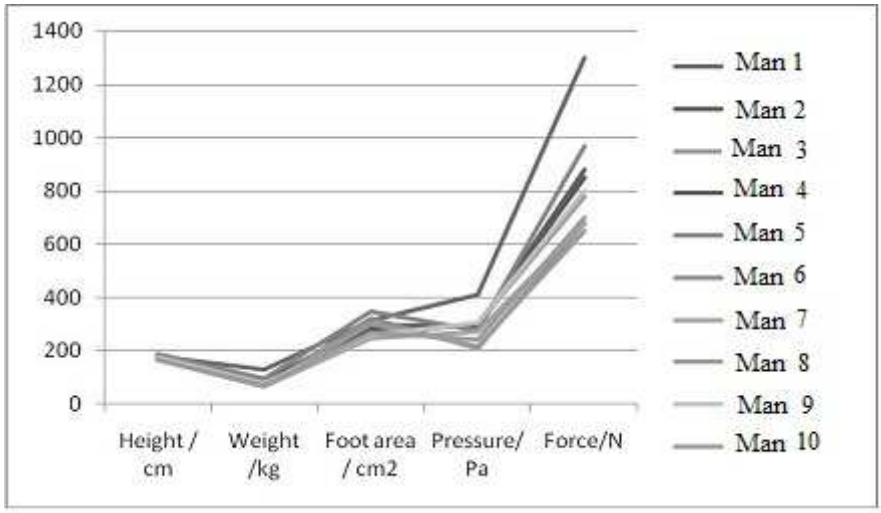

Figure 7: Graphic display measures in mans

Figure 8. shows the measurements data of height, weight, foot area, pressure and force for womans.

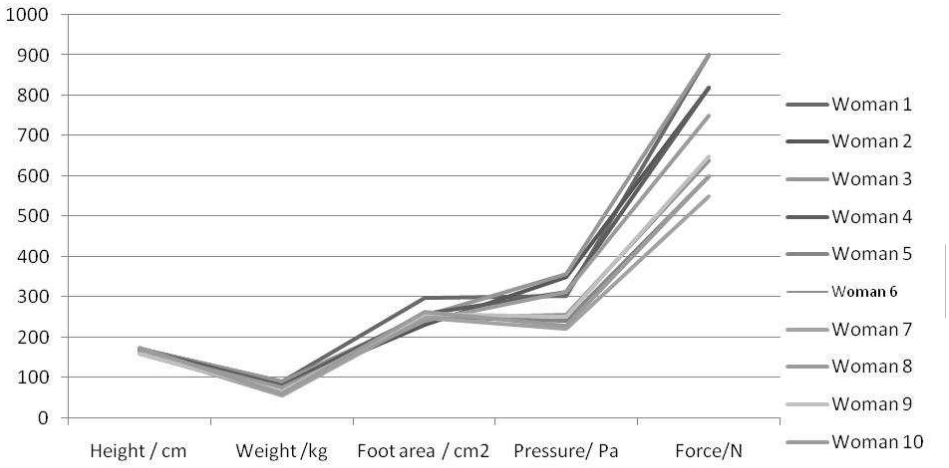

Figure 8: Graphic display measures in womans

5. CONCLUSION

We decided, that people with bigger body weight, produce higher foot pressure, making bigger force on the surface no matter male or female. Appropriate shoes have big meaning in human life, and for that, shoes has to be remodeled to avoid places with high contact pressures, places inside the foot with concentrated strain [6]. Places like that are with blisters, swells, wounds, uneven geometric foot form because biomechanics on goings while walking are very complex. With mechanical on goings such as gravity force, inertia and pressure, we are able to walk and keep our balance [9].

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