

## THE IMPACT OF NIGHT SHIFT ON THE WORK ABILITY OF EXPOSED WORKERS

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**Abstract.** *The exposed group included 200 workers who work night shifts. The control group included 180 workers who work only in the first shift. It was observed that a significant number of workers in the exposed group had conditions related to infectious, malignant, mental, hematopoietic, immune, endocrine, nervous, cardiovascular, respiratory, gastrointestinal, musculoskeletal, and skin diseases. When compared to the control group, the exposed group had a statistically significantly higher number of workers suffering from two or more diseases at the same time. Work ability index (WAI) was statistically significantly higher among the workers of the control group compared to the workers of the exposed group. It was determined that the WAI value decreases with the length of service in the exposed group and that this decrease is more prominent after the eleventh year of service. In the control group, no decrease in WAI was registered with length of service.*

**Key words:** *night work, work ability, gender, diseases, length of exposure.*

### 1. INTRODUCTION

With the development of society and the emergence of new industrial-technological achievements, shift and night work has become inevitable, not only in industry, healthcare, the army and the police, but also in social occupations such as entertainment and services. It is estimated that 10-30% of the workforce in the US and Europe, and a fifth of the world's population, are engaged in jobs that require shift or night work. [1,2,3].

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Numerous studies have been conducted to examine the influence of night work on the physical and psychological health of employees. Shift work, especially at night, is one of the most common factors that disrupt the circadian rhythm [4,5], leads to sleep and wakefulness disorders [6,7], diseases of the cardiovascular system [8,9,10,11,12], diseases of the respiratory system [13,14], endocrine system disorders [15,16,17,18], gastrointestinal [19,20,21], reproductive [22,23,24], musculoskeletal apparatus [25,26,27], cerebrovascular [28] and the immune system [29]. There is evidence that night shift work increases inflammatory processes in the body [30], affects mental health [31,32,33], and nervous system [34,35], disrupts nutrition [36,37,38], leads to metabolic disorders [39,40,41,42], obesity [43,44], disrupts vitamin D synthesis [45,46,47], and is associated with a more frequent occurrence of malignant diseases [48,49,50,51]. During night work, the worker's psycho-physical well-being is disturbed, there is a decrease in attention, a decrease in cognitive functions [52,53,54] and a tendency to injury [55,56].

## 2. AIM

The aim of the research was to examine how working night shifts affected the work ability of exposed workers.

## 3. METHODOLOGY

The study included 200 workers who work night shifts (exposed group) and 180 workers who work only first shift (control group). The workers were examined as part of the expert assessment of work ability at the Institute of Occupational Health Niš by a multidisciplinary team consisting of a specialist in occupational medicine, as well as specialists in neurology, psychiatry, ophthalmology, and a psychologist. Each employee provided anamnestic data (subjective complaints, work, personal, family and social history), and they underwent a clinical examination by systems, blood pressure measurement, auscultation of the heart and lungs, laboratory analyses (erythrocyte sedimentation rate, blood count, blood sugar levels, lipids, electrolytes, urea, creatinine, transaminases, gamma GT), as well as electrocardiographic examination, ultrasound examination, and spirometry. The data from the Risk Assessment Act and the medical records were also analysed. Working ability was assessed by the Work Ability Index (WAI) questionnaire [57]. It contains seven items, with each item accounting for a partial score that contributes to the overall working ability score, ranging from 7 to 49. The seven items measure the following variables: (1) current working ability compared with lifetime best (range: 1–10), (2) working ability in relation to mental and physical demands of the job (range: 2–10), (3) number of current diseases diagnosed by a physician (range: 1–7), (4) estimated work impairment due to diseases (range: 1–6), (5) sick leave during the past 12 months (range: 1–5), (6) self-prognosis of working ability for the next 2 years (scores: 1, 4, or 7), and (7) mental resources (range: 1–4). The overall score refers to four categories of scores: 7–27 points (bad working ability) to restore work Ability, 28–36 points (moderate working ability) to improve work ability, 37–43 points (good working ability) to support work ability, and 44–49 points (very good working ability) to support work ability as described in our previous investigations [58]. The data were analysed for statistical significance by using the statistical package of social science (SPSS 11.0 Systat 8.0) software.

## 4. RESULTS

The workers of the examined and control group were similar in structure in relation to age, gender and length of service. The average age of workers in the exposed group was  $47.81 \pm 3.22$  years and the average age of workers in the control group was  $48.02 \pm 2.98$  years, which does not represent a statistically significant difference. The average length of service of the subjects of the exposed group was  $20.23 \pm 2.75$  years and the workers of the control group  $20.35 \pm 2.63$  years, which also does not represent a statistically significant difference (Table 1).

**Table 1** Structure of workers in the exposed and control group in relation to age and years of service

	Exposed group (N=200)			Control group (N=180)			p
	N	X	SD	N	X	SD	
Age (years)	200	47.81	3.22	180	48.02	2.98	n.s
Years of service	200	20.23	2.75	180	20.35	2.63	n.s

n.s - not significant

There were 117 (58.5%) men and 83 (41.5%) women in the exposed group, which is not a statistically significant difference compared to the control group (58.9% men and 41.1% women) (Table 2).

**Table 2** Structure of workers in the exposed and control group in relation to sex

Sex	Exposed group (N=200)			Control group (N=180)			p
	N	Number	%	N	Number	%	
Man	200	117	58.5	180	106	58.9	n.s
Woman	200	83	41.5	180	74	41.1	n.s
Total	200	200	100.0	180	180	100.0	

n.s - not significant

Analysis of the number of respondents in relation to belonging to a specific age subgroup of work experience (0-10 years; 11-20 years; 21-30 years; 31-40 years) shows that there are no statistically significant differences between the exposed and control groups (Table 3).

**Table 3** Structure of workers in the exposed and control group in relation to years of service

Years of service	Exposed group (N=200)		Control group (N=180)		p
	Number	%	Number	%	
0-10	52	26.0	46	25.5	n.s
11-20	49	24.5	44	24.4	n.s
21-30	51	25.5	48	26.7	n.s
31-40	48	24.0	42	23.3	n.s
Total	200	100.0	180	100.0	

n.s - not significant

In the exposed group, a greater presence of workers suffering from infectious, malignant, mental, diseases and diseases of the hematopoietic, immune, endocrine, nervous, cardiovascular, respiratory, gastrointestinal, musculoskeletal systems and diseases of the eye, ear and skin was registered. This difference is statistically significant for the number of patients with diseases of the blood, immune and circulatory system ( $p < 0.05$ ) (Table 4).

**Table 4** Detected diseases and related health problems in workers of the exposed and control group

Disease or related health problem (according to ICD-10)	Exposed group (N=200)		Control group (N=180)		p
	Number	%	Number	%	
Certain infectious and parasitic diseases	31	15.5	14	7.7	n.s
Neoplasms	19	9.5	7	3.9	n.s
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	17	8.5	5	2.8	$p < 0.05$
Endocrine, nutritional and metabolic diseases	33	16.5	17	9.4	n.s
Mental and behavioural disorders	29	14.5	16	8.9	n.s
Diseases of the nervous system	13	6.5	7	3.9	n.s
Diseases of the eye and adnexa	27	13.5	12	6.7	n.s
Diseases of the ear and mastoid process	21	10.5	11	6.1	n.s
Diseases of the circulatory system	79	39.5	41	22.7	$p < 0.05$
Diseases of the respiratory system	27	13.5	16	8.9	n.s
Diseases of the digestive system	23	11.5	13	7.2	n.s
Diseases of the skin and subcutaneous tissue	21	10.5	17	9.4	n.s
Diseases of the musculoskeletal system and connective tissue	55	27.5	34	18.9	n.s
Diseases of the genitourinary system	19	9.5	12	6.7	n.s
Without diseases	117	58.5	131	72.3	n.s

n.s - not significant

In the exposed group, there was a statistically significantly higher number of workers suffering from two or more diseases at the same time compared to the subjects of the control group (Table 5).

**Table 5** Number of detected diseases and related health problems in workers of the exposed and control group

	Exposed group (N=200)		Control group (N=180)		p
	Number	%	Number	%	
Without disease	117	58.5	131	72.3	n.s
With one disease	41	20.5	29	16.1	n.s
With two or more diseases	42	21.0	20	11.1	$p < 0.05$
Total	200	100.0	180	100.0	

n.s - not significant

Work ability index (WAI) was statistically significantly higher among the workers of the control group ( $39.4 \pm 3.81$ ) compared to the workers of the exposed group ( $31.8 \pm 2.53$ ) ( $p < 0.0001$ ). It was determined that the WAI value decreases with the length of

service in the exposed group and that this decrease is particularly pronounced after the eleventh year of service. No reduction is registered in the control group WAI with the length of service (Table 6).

**Table 6** WAI in exposed and control groups in relation to years of service

Years of service	Exposed group (N=200)			Control group (N=180)			p
	N	X	SD	N	X	SD	
0-10	52	39.8	3.02	46	39.9	4.52	n.s
11-20	49	33.5	2.98	44	39.8	3.01	p<0.0001
21-30	51	29.4	2.31	48	38.9	2.98	p<0.0001
31-40	48	23.8	1.98	42	38.1	2.76	p<0.0001
Total	200	31.8	2.53	180	39.4	3.81	p<0.0001

n.s - not significant

Men in the exposed group had a statistically significantly lower work ability index ( $33.8 \pm 2.84$ ) compared to men in the control group ( $39.8 \pm 3.98$ ) ( $p < 0.0001$ ). Women in the exposed group had a statistically significantly lower work ability index ( $28.9 \pm 2.28$ ) compared to women in the control group ( $38.8 \pm 3.75$ ) ( $p < 0.0001$ ) (Table 7).

**Table 7** WAI at workers of exposed and control group in relation to sex

Sex	Exposed group (N=200)			Control group (N=180)			p
	N	X	SD	N	X	SD	
Man	117	33.8	2.84	106	39.8	3.98	p<0.0001
Woman	83	28.9	2.28	74	38.8	3.75	p<0.0001
Total	200	31.8	2.53	180	39.4	3.81	p<0.0001

In the exposed group, men had a statistically significantly higher WAI ( $33.8 \pm 2.84$ ) than women ( $28.9 \pm 2.28$ ). In the control group, the difference in WAI between men ( $39.8 \pm 3.98$ ) and women ( $38.8 \pm 3.75$ ) was not statistically significant (Table 8).

**Table 8** WAI in relation to sex at workers of exposed and control group

	Sex						p
	Man			Woman			
	N	X	SD	N	X	SD	
Exposed group (N=200)	117	33.8	2.84	83	28.9	2.28	p<0.0001
Control group (N=180)	106	39.8	3.98	74	38.8	3.75	n.s.

Healthy workers had the highest index of work ability both in the exposed ( $34.9 \pm 2.93$ ) and in the control group ( $40.8 \pm 3.98$ ). Workers with one registered disease had a higher work capacity index than workers with two or more diseases in both the exposed and control groups. Workers of the control group of all categories (without disease; with one disease; with two and more diseases) had a statistically significant higher index of work ability compared to workers of the same categories of the exposed group ( $p < 0.0001$ ) (Table 9).

Table 9 WAI in exposed and control groups in relation to number of the diseases

Years of service	Exposed group (N=200)			Control group (N=180)			p
	N	X	SD	N	X	SD	
Without disease	117	34.9	2.93	131	40.8	3.98	p<0.0001
With one disease	41	30.7	2.32	29	38.5	2.75	p<0.0001
With two or more diseases	42	24.2	1.78	20	31.5	2.85	p<0.0001
Total	200	31.8	2.53	180	39.4	3.81	p<0.0001

n.s - not significant

## 5. DISCUSSION

Work capacity is the ability to perform a specific job that can be valued in the labor market. It implies the ability of a worker to arrive at their workplace, complete tasks, leave their workplace and successfully respond to all job requirements without jeopardizing their health and health and safety of other workers. In addition to professional knowledge, experience, skills and qualifications for performing a certain job, there are additional factors that are significant for performing a particular job, such as the state of health and the functional state of engaged organs and organ systems, psychophysical abilities, motivation for work, habits, family circumstances, social environment, marital condition, age, climatic conditions, presence of occupational risks (noise, vibrations, chemical risks, stressful factors, radiation, lighting, microclimatic conditions, biological agents, dust), workplace requirements (physical effort, shift work, standard work, at a height, non-physiological position of the body), the way of getting to and from work. The opinion on working capacity is made based on the worker's health condition, the functional capacity of their involved organs and organ systems, particular requirements of their job and the presence of professional risks [59,60]. The goal of this research is to assess the impact of night shift work on the work ability of exposed workers. The WAI questionnaire was used as an instrument for assessing work ability since it analyses the largest number of factors that affect work ability. According to data from the literature, working the night shift reduces workers' psychophysical capacities, which are key aspect in their ability to work. To support this, Maltese F and colleagues proved that the cognitive abilities of doctors significantly changed after a night shift in intensive care, regardless of their professional experience or the amount of sleep during the shift [61]. In his research, Fischer FM showed that the working ability of people who work the night shift is significantly determined by socio-demographic factors (earnings, raising children, age), working conditions (microclimate, workplace organization and verbal abuse) and health parameters (high body mass index, obesity, sleep problems and fatigue) [62]. Research by Nishimura Y and colleagues shows that working on the night shift significantly reduces the cognitive ability, reaction time and self-control ability of nurses, which significantly affects the safety and health of nurses [63]. Many studies have demonstrated that fatigue, tiredness and decreased quality of life are significant consequences of night shift work [64,65,66,67,68] and these consequences are much more severe in older workers [69,70,71]. Night shift work has been linked to the incidence of disorders affecting nearly all organs and organ systems. The presence of these diseases in workers further reduces the functions of organs and organ systems, which in turn reduces the ability to work. Diseases of all systems and organs were

found to be more common in this study, but there is statistically significant difference for diseases between the diseases in the group "Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism" and "Diseases of the circulatory system". Daytime sleep is approximately 2 hours shorter than night sleep for people who work the night shift and is not of the same quality as night rest and sleep. Workers who work at night frequently report sleepiness, chronic fatigue, irritation, tension, and non-physiological rhythm of work and rest, and more often suffer from insomnia, depression, anxiety, and bipolar disorder [72]. In addition, night work also causes gastrointestinal disturbances since enzyme secretion during the night is not the same as during the day. Workers who work at night complain more about dyspeptic disorders, nausea, stomach pain, and constipation. Many gastrointestinal diseases, such as peptic ulceration, Crohn's disease, and ulcerative colitis, deteriorate with long-term night work, which significantly affects one's capacity to work. Diabetes mellitus and other endocrine diseases are more difficult to control if the worker works at night, which increases the risk of complications of these diseases [73]. Night shift workers are at higher risk of developing cardiovascular disease, ischemic heart disease and arterial hypertension. This is explained by elevated blood fats, excessive obesity, bad habits (smoking, alcohol) and sleep disturbance, which adversely affects the cardiovascular system. Diseases of the circulatory system significantly reduce the functional work capacity and working ability of the affected workers [74]. Angina pain attacks occur more often during the night due to the predominance of the parasympathetic system [75,76,77]. Workers who suffer from asthma and work at night have more frequent asthmatic attacks due to increased bronchial hyperreactivity at night, which worsens respiratory function and work ability. Inflammatory diseases are significantly aggravated during night shift work because cortisol levels are lower at night than they are during the day [78]. A large number of studies in the world have examined the relationship between circadian rhythm and malignant diseases and their impact on work ability. Studies report higher risks of breast cancer and colorectal cancer after long-term night shift work. It is believed that every cell in the human body has a biological clock that is controlled by the circadian rhythm. Melatonin, a strong antioxidant that reduces free radical levels and inhibits the growth and proliferation of tumor cells, regulates the gene for cell proliferation and apoptosis. Unfortunately, melatonin levels in night workers are lower than normal [79,80]. In practice, during the assessment of their working capacity, sick workers are exempted from working the night shift for medical reasons, and the percentage of workers declared unable to work the night shift due to illness is usually around 2.5% [81]. This research showed that women are more sensitive and have difficulties to sustain night work than men, can be attributed to their heavier family responsibilities and insufficient daytime sleep. Night shift work disrupts ovarian hormone secretion, which disturbs both the circadian and menstrual cycles, resulting in women who work the night shift experiencing health issues more frequently than men [82,83,84,85].

## 6. CONCLUSION

Working the night shift significantly reduces work ability and women are especially vulnerable to its consequences, as do individuals with specific diseases. The consequences of night work on reduced working capacity increase with the length of exposure, and workers who have worked at night for more than 11 years are especially sensitive to this impact.

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## **UTICAJ RADA U NOĆNOJ SMENI NA RADNU SPOSOBNOST EKSPONOVANIH RADNIKA**

*Eksponovanu grupu je činilo 200 radnika koji rade u noćnim smenama. Kontrolnu grupu je činilo 180 radnika koji rade samo u prvoj smeni. U eksponovanoj grupi je registrovano prisustvo većeg broja radnika koji pate od infektivnih, malignih, mentalnih, bolesti i oboljenja hepatopoeznog, imunog, endokrinog, nervnog, kardiovaskularnog, respiratornog, gastrointestinalnog, muskuloskeletnog sistema, bolesti oka, uva i kože. U eksponovanoj grupi je bio statistički značajno veći broj radnika koji pate istovremeno od dve ili više bolesti u odnosu na ispitanike kontrolne grupe. Indeks radne sposobnosti (WAI) je bio statistički značajno veći kod radnika kontrolne u odnosu na radnike eksponovane grupe. Utvrđeno je da sa dužinom radnog staža u eksponovanoj grupi opada vrednost WAI i da je ovaj pad naročito izražen posle jedanaeste godine radnog staža. U kontrolnoj grupi se ne registruje smanjenje WAI sa dužinom radnog staža.*

**Ključne reči:** rad u noćnoj smeni, radna sposobnost, pol, bolest, dužina ekspozicije