# Work Ability Index of Forestry Machine Operators and some Ergonomic Aspects of their Work

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***Abstract – Nacrtak***

*This paper provides the results of an applied research of forestry machine operators related to their work ability index (WAI) and some ergonomic aspects of their everyday work. A questionnaire on work environment and working ability was conducted in the year 2012 and included machinery operators employed in the state forestry company Croatian Forest Ltd. and in private forestry companies. Descriptive statistics and comparisons have been carried out regarding work ability index and frequency response of the respondents. The first part of the results presents a) profile of respondents b) organization of operators' work activities and their education, c) impact of tiredness and d) impact of psychological and social factors on operators' work ability. The second part of the results presents a) work ability results in relation to demographic categories of respondents and b) examination of differences between work ability indexes by groups of descriptive variables. Regarding the educational aspect of the sampled machine operators, the results showed insufficient level of adequate specialized education. Higher level of mental demands required to perform the job was rated with the operators employed in private companies. Demographic parameters of the respondents negatively affect the working and functional ability of forestry machine operators, and the value of operators' WAI decreased considerably within the groups depending on work experience in the private forestry sector.*

*Keywords: forestry, machine operators, work ability index, working environment*

## 1. Introduction – *Uvod*

Skidding and/or forwarding of timber are considered to be technically demanding, the most expensive, and together with felling and cutting, the riskiest everyday operations in forestry. Within the process of timber harvesting, a group of work operations during skidding/forwarding, which are also called the primary transport (Poršinsky 2005), are defined as removal of whole trees or their parts from the felling site (stump) to the roadside landing using a forest machine. Requirements for volume and quality of forest works, especially works concerning skidding and forwarding, are ever increasing. At the same time, forest work and supporting logistics processes become more complex, and certification of forest management goes with a wide number of requirements on the quality of performance, especially in terms of stand protection and biodiversity conservation (Kostenholtz et al. 2008), as well as social and safety standards of workers in direct production. Development of forest technology at the end of the 20$^{th}$ century and structural changes in forestry sector (market growth, denationalization, etc.) have led to a significant reduction in the number of employees in the state forestry sector and also to the development of new business models in some segments, such as exploitation of forests, where entrepreneurship plays a dominant role.

Forest contractors become an important link between forest owners and wood industry (Šporčić 2005) in Europe and in Croatia. In the period 2000–2010, there has been a visible increase in contractors' services in the state forests of the Republic of Croatia (RC). Contractors have a constant share of 41.83% in skidding/forwarding operations, which means that

the company Croatian Forests Ltd. Zagreb (in charge for the management of state forests) extracts with its own mechanization approximately 58.17% of timber (Landekić et al. 2011b). The volume of services that private contractors provide to private forest owners in Croatia is not registered and no reliable data concerning these activities are available. Engagement of forest contractors and transition to contract work brings some benefits (flexibility, better financial result, better work performance due to specialization, etc.), but also defects such as insufficient investment in equipment and training, questionable professional level of work, low safety level, questionable effectiveness of workers' health care, ineffective labor inspection (Šporčić et al. 2009) and potentially less skillful machine operators in the private sector.

The key role for ensuring competitiveness of timber extraction (skidding/forwarding), but also for achieving a satisfying level of safety and efficiency in forest production, lies in work ability and working techniques used directly by forestry machine operators (Martinić et al. 2011). Vaguely specified legal responsibility of forest contractors and inefficiency of labor inspection leads to negligence of basic safety standards, which may result in inadequate working environment and reduced working ability of operators employed in private forestry sector. This is why in this paper the ergonomic aspects were investigated and compared of the working environment and working ability of forestry machine operators who are employed by private contractors in forestry on the one side, and those employed in the state company Croatian Forests Ltd. Zagreb (CF Ltd.) on the other side. The working ability of operators is researched and presented through the work ability index (WAI), and the ergonomic characteristics of the working environment are measured through the respondents' answers on the training process, exposure to physical hazards (noise and vibration), impact of fatigue on work ability and also on their assessment of psychological and social factors of the working environment.

## 2. Issues and objectives of research *Problematika i ciljevi rada*

Forest work is highly dangerous and risky, and the work environment that implies working outdoors hides many hazards. The group of work operations related to timber skidding and/or forwarding is technically demanding, the most expensive, and after felling and cutting to length the most risky among everyday forest operations (Ranogejec et al. 2010). Insight into the real conditions of work safety and humanization of work activities in timber extraction, in the form of ergonomic, technical and organizational solutions, is a starting point for the process of improving ergonomic features of the working environment and work ability of machine operators in forestry.

Satisfactory ergonomic level in terms of working environment and high working ability of forestry machine operators, in compliance with safety rules for mechanized skidding, seems crucial for creating safe working conditions in order to prevent physical fatigue, monotony of work and work-related injuries. Analysis of ergonomic characteristics of the working environment and numerical evaluation of machine operators' work ability in forestry is the first step in the evaluation of the current situation, which should later result in proposing the necessary measures to improve the safety system and security levels of timber extraction. The main task of this research is to determine the work ability index (WAI) of machine operators employed in the state and private forestry sector and to establish the ergonomic features of the working environment, as well as opportunities to improve the current situation in forestry operations.

## 3. Material and methods – *Materijal i metode*

Forest machine operators in Croatian forestry, employed by the state-owned company Croatian Forests Ltd. as well as those employed by private forest contractors, are the primary object of research. Investigation of ergonomic requirements of the working environment and research on work ability of machine operators engaged in timber extraction included the current theoretical understanding and views of operators using the survey method. The source and model used to create a survey questionnaire were the documents under the title *»The Machine Operator Current Opinions and the Future Demands on Technical Ergonomics in Forest Machines«* (Walker et al. 2001). Another relevant source refers to a document under the title *»Work Ability Index«* (Tuomi et al. 1998), which was developed by the Finnish Institute of Public Health.

### 3.1 Survey method and structure of the measuring instrument – *Metoda anketiranja i struktura mjernoga instrumenta*

The survey method is a process based on a survey questionnaire, which investigates and collects data, information, views and opinions about the subject of research (Čekić 1999). There are numerous ways to conduct a survey questionnaire, and some of the most used are as follows: on-line or web surveys, e-mail

surveys, computer-aided telephone interviewing, etc. The answer to a particular question from the survey is valuable to the extent to which it is associated with the opinion or attitude on a topic. Questionnaires, in relation to interviews, are usually viewed as a more objective research tool that can produce generalizable results because of large sample sizes (Oppenheim 1992).

For the investigation of the working environment ergonomics and work ability of forestry machine operators, the questionnaire developed by the Department of Forest Engineering at the Faculty of Forestry in Zagreb was used. The survey was conducted during the year 2012 as a part of activities on the project entitled *»Licensing and Certification for Acquiring European Standards of Safety and Quality at Forestry Work«* initiated and financed by Croatian Forests Ltd. Before the questionnaire was distributed, all required steps and preparations had been performed with the goal to ensure reliability and credibility of the survey.

The questionnaire consists of five structural parts, and contains 48 questions. The first structural part of the questionnaire is related to the collection of personal data about respondents (gender, age, qualifications, etc). The second part of the questionnaire covers the current employment and organization of machine operators' daily work activities. The third section of the questionnaire examines the presence and development of disease and fatigue, while the fourth section is related to the impact of psychological and social factors on forestry machine operators. Within the first four structural parts, questions were designed to measure separate variables. The fifth part of the questionnaire involves the assessment of work ability index (WAI) for forestry machine operators through 7 standardized questions. In the questionnaire, the following answers to the questions were used: a) yes/no answer b) multiple answers c) Likert scale evaluation and d) questions with open answers.

Stratified sampling method was used to divide up the population ($N = 150$) into two smaller non-overlapping sub-groups: (a) operators in CF Ltd. ($N = 75$) and (b) operators in private forest companies ($N = 75$). In each sub-group a simple random sample was done by Sample Size Calculator. During the analysis and processing of collected data, the following methods were used: statistical method, method of generalization, description and comparison. Graded, collected and summarized data for the assessment of working and functional abilities of forestry machine operators (the fifth part of the questionnaire) are expressed through the work ability index (WAI). Database for entry of collected data, systematization, verification of input accuracy and primary processing of data was made in Microsoft Office Excel. Statistical analysis was performed using statistical software: *Statistica 8* and *SPSS 17.0* – Statistical Package for Sociological Research. Rank correlation was used to measure the relationship between variables and alternative nonparametric analysis of variance (Kruskal–Wallis test) was used to test the differences between groups of variables. Based on individual observations, generalized conclusions were drawn up using the analysis of a limited number of subjects in the base sample.

### 3.2 Work ability index in general – *Indeks radne spremnosti općenito*

Working and functional ability cannot be objectively measured with a single instrument. It always requires an assessment based on data obtained from several different sources (medical examination, survey, testing, etc.). Work Ability Index (WAI) is an instrument designed for practical application, widely used by healthcare workers or health and safety employees, like a help tool for determining employees working competence, as a basis for further measurements (Tuomi et al. 1998). WAI is a result of workers own assessment of his or her work readiness. The instrument, developed by the *Finnish Institute of Public Health*, is easy and quick to use, cyclically repeatable, results are obtained quickly and can be used for monitoring on the level of individuals or groups (e.g. department, age or professional groups, etc.). It is applicable within health and safety system, where it shows how well an employee is able to perform his daily job duties. It can be used for the assessment of working and functional ability in the framework of medical examination or as a survey at the workplace. The instrument based on a questionnaire is intended for workers support: a) where it can be used at an early stage to ensure proper measures to maintain working readiness or b) it can help in determining workers who need healthcare support at work. Responding to a series of seven questions (Table 1), which take into account physical and mental demands of the job, it gives the result ranging between 7 and 49 points (Table 1), which illustrates numerically the working and functional ability of each participant. This approach establishes optimal conditions to prevent premature reduction of work ability.

Steps and measures directed toward restoring work ability or additional evaluations of work ability are needed by those whose work ability is graded poor (maximum score 27). For those whose work ability is moderate (score 28–36), measures to help improve work ability are recommended. Workers with a good work ability index (score 37–43) should receive instructions on how to maintain their work ability. Those

**Table 1** Items of the Work Ability Index (Ilmarinen 2007)
***Tablica 1.*** *Stavke indeksa radne spremnosti (Ilmarinen 2007)*

| | Items – *Stavka* | Range – *Raspon* |
|---|---|---|
| 1 | Current work ability compared with the lifetime best – *Sadašnja radna spremnost u odnosu na najbolju životnu* | 0–10 |
| 2 | Work ability in relation to the demands of the job – *Radna spremnost u odnosu na zahtjeve posla* | 2–10 |
| 3 | Number of current diseases diagnosed by a physician – *Broj bolesti koje je dijagnosticirao liječnik* | 1–7 |
| 4 | Estimated work impairment due to diseases – *Procijenjena radno umanjenje zbog bolesti* | 1–6 |
| 5 | Sick leave during the past year (12 months) – *Broj dana bolovanja u protekloj godini (12 mjeseci)* | 1–5 |
| 6 | Own prognosis of work ability 2 years from now – *Vlastita prognoza radne sposobnosti za buduće 2 godine* | 1–7 |
| 7 | Mental resources – *Mentalni resursi* | 1–4 |

whose work ability is excellent (44–49) should also be informed about which work and life-style factors maintain work ability and which factors weaken it (Tuomi et al. 1998). The index can also be used to predict the threat of disability in the near future.

## 4. Results and findings of research *Rezultati i nalazi ispitivanja*

In the present study, analysis of opinions and attitudes of the forestry machine operators included: a) profile analysis of the respondents in the study; b) main findings of the second, third and fourth structural part of the questionnaire related to the working environment of machine operators, c) values of the machine operators work ability index and comparison of WAI with demographic categories of respondents.

### 4.1 Profile of respondents – *Profil ispitanika*

Forestry machine operators employed in the state and private forestry sector were selected as participants in the research conducted on the ergonomic features of the working environment and work ability index. First, 75 questionnaires were delivered to forestry machine operators employed in working units engaged in mechanization, transport and building, and also to the forest offices which have their own mechanization, within forest administration Požega, Našice, Zagreb and Karlovac, as a part of the company Croatian forests Ltd. Another 75 questionnaires were delivered to machine operators employed in private forestry sector, which were engaged in timber extraction on the territory of the forest administration Našice, Zagreb and Sisak at the time of survey. 44.67% of forestry machine operators answered the questionnaire (Table 2), which is satisfactory feedback in terms of the research.

The profile and characteristics of the operators surveyed in the state forestry sector, according to several criteria (gender, age group, qualifications), roughly correspond to the total number of employees working as machine operators in the company Croatian forests Ltd. Zagreb. A higher share of younger machine operators is visible in private forestry sector. Also, within the sample, difference in the level of machine operators' education is notable. In the private sector, the operators' education level is significantly higher than that of operators employed in Croatian forests Ltd. (Table 2).

### 4.2 Aspect of Working Environment of Forestry Machine Operators in Croatia– *Aspekt radnoga okoliša kod rukovatelja mehanizacijom u Hrvatskoj*

To plan for and control environmental and ergonomic aspects of forestry machine operators work, it is necessary to know what impacts them and where these impacts come from. Consequently, ergonomic characteristics of the working environment are examined and presented through the attitudes of the forest machinery operators concerning a) education and organization of operators work activities, b) impact of tiredness and c) impact of psychological and social factors on operator work ability. Identification and efficient management of environmental aspects and impacts should result in positive influence on employees in practice and also in significant environmental improvements.

#### 4.2.1 Employment, education and organization of work activities – *Zaposlenost, osposobljenost i organizacija rada*

For decades, training and periodically checking the qualification of forestry machine operators have been considered as the key activities for ensuring the work

**Table 2** General information about the respondents
***Tablica 2.*** *Opći podatci o ispitanicima*

| Type of interviewees – *Vrsta ispitanika* | | Forestry machine operators (private and state sector) *Rukovatelji šumarskom mehanizacijom (privatni i državni sektor)* | | | |
|---|---|---|---|---|---|
| Number of respondents – *Broj odgovora* | | 67 (44.67%) | | | |
| Time of research – *Vrijeme ispitivanja* | | During 2012 – *Tijekom 2012. godine* | | | |
| Profile of interviewees – *Profil anketiranih zaposlenika* | | Croatian Forests Ltd. *Hrvatske šume d.o.o.* | | Private forest company *Privatna šumarska tvrtka* | |
| | | 39 (52.00%) | | 28 (37.33%) | |
| | | *N* | % | *N* | % |
| Gender *Spol* | Male – *Muški* | 39 | 100.00 | 28 | 100.00 |
| | Female – *Ženski* | 0 | 0.00 | 0 | 0.00 |
| Age group *Dobna skupina* | <25 | 1 | 3.00 | 7 | 25.00 |
| | 25–35 | 10 | 26.00 | 7 | 25.00 |
| | 35–45 | 14 | 36.00 | 8 | 29.00 |
| | 45–55 | 12 | 31.00 | 5 | 28.00 |
| | 55< | 2 | 5.00 | 1 | 4.00 |
| Level of education *Stručna sprema* | Unqualified (worker) – *Nekvalificirani (radnik)* | 18 | 46.00 | 5 | 18.00 |
| | Qualified (worker) – *Kvalificirani (radnik)* | 6 | 15.00 | 9 | 32.00 |
| | Secondary education – *Srednja školska sprema* | 15 | 38.00 | 12 | 43.00 |
| | University degree – *Visoka stručna sprema* | 0 | 0.00 | 2 | 7.00 |

quality and safety of operational forest work. In most European countries, regulations oblige employers to provide adequate training to each person using the working tools and machines (Medved 1998). The research results of professional education of operators in the sample (Table 3) show that 56.41% of operators in CF Ltd., and 33.00% of operators employed by private contractors have no adequate professional experience or specialized education. The reason why the level of education is low is the lack of formal regulations and bodies that provide certification of knowledge and skills of forestry machine operators in Croatia.

Knowledge, skill and experience in operating forest machinery are the basic items in the operator career development. By comparing the professional experience of the respondents (Fig. 1), it can be seen that operators employed by the company CF Ltd. have on average more work experience as forwarder operators, skidder operators and as forest cutters. The reason for this result is noticeably older population of respondents employed by the CF Ltd. (average age mean in CF Ltd = 42.33 years, and in private sector = 35.79 years) with about 1/3 higher overall professional ex-

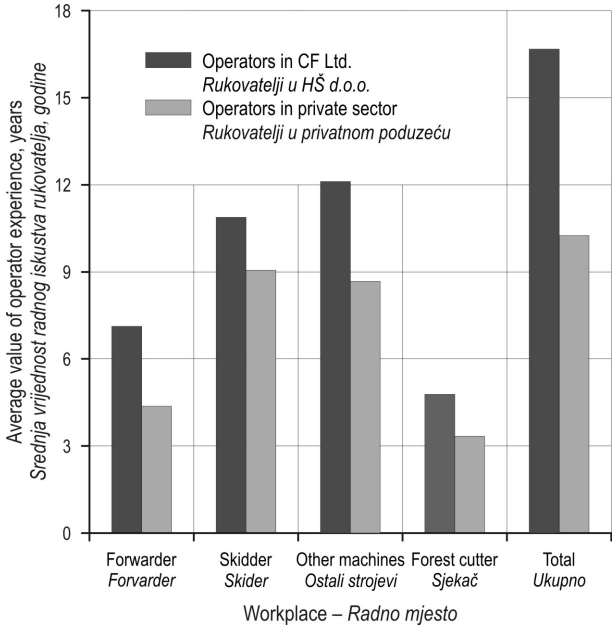


**Fig. 1** Professional experience of operators by workplace
***Slika 1.*** *Godine profesionalnoga iskustva rukovatelja prema mjestu rada*

**Table 3** Type of education related to machine control
***Tablica 3.*** *Vrsta obrazovanja vezana uz upravljanje mehanizacijom*

| Offered response – *Ponuđeni odgovor* | Croatian Forests Ltd. *Hrvatske šume d.o.o.* | | Private forest company *Privatna šumarska tvrtka* | | Total *Ukupno* | |
|---|---|---|---|---|---|---|
| | *N* | % | *N* | % | *N* | % |
| Self-educated – *Samoobrazovan* | 22 | 56.41 | 9 | 33.00 | 31 | 48.00 |
| Vocational experience – *Strukovno iskustvo* | 9 | 23.08 | 17 | 63.00 | 25 | 38.00 |
| Specialized education – *Specijalističko obrazovanje* | 8 | 20.51 | 1 | 4.00 | 9 | 14.00 |

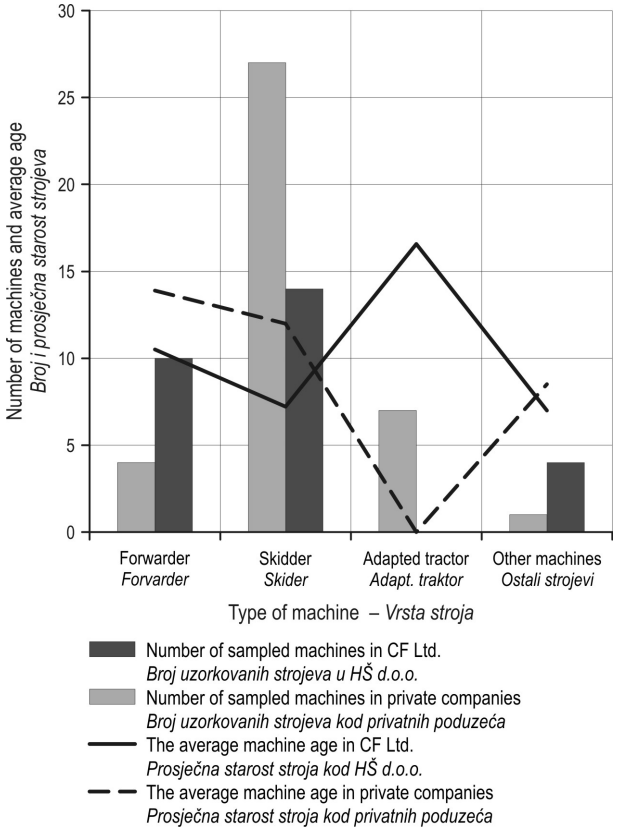


**Fig. 2** Number and average age of machinery operated by sampled operators
***Slika 2.*** *Broj i prosječna dob mehanizacije kojom upravljaju uzorkovani rukovatelji*

perience in forestry (Fig. 1). On the other hand, the sample shows that operators employed by the CF used more commonly skidders for timber extraction (Fig. 2), and that the average age of machines (forwarders and skidders) is considerably lower than the age of machinery owned by private contractors in forestry. In timber extraction, different methods are applied for removing different forms of assortments: from cut-to-length method (almost always with forwarders), through stemwood, halfwood to whole tree methods.

Adequate work organization can proactively act to increase the level of performance of the forestry machine operators. Research results on work techniques training for the mechanized timber extraction (Table 4) show that the operators employed by private contractors have a higher level of training (29.85%). Exposure to excessive noise and vibration in the working environment was rated with 32.14% by respondents employed in the private sector and 41.03% by respondents employed in CF Ltd (Table 4). The lack of personal protective equipment (PPE) was rated with 32.14% by respondents employed by private contractors, and 50.00% said that they do not use it every day to the full extent. On the other hand, in the company CF Ltd. only 5.13% of the respondents indicated a lack of personal protective equipment, and 43.59% said that they do not use it every day to the full extent. The occurrence of pain and discomfort (Table 4) caused by the position of the body when working was noted by 16 operators employed in CF Ltd. and 12 operators employed in the private forestry sector.

#### 4.2.2 The impact of fatigue and development of disease among respondents – *Utjecaj zamora i razvoj bolesti kod ispitanika*

*Tiredness* and *fatigue* can have a significant adverse *impact* on organizational efficiency and productivity as well as operators' health and safety. Assessment of the impact of physical fatigue on the quality and productivity of machine operators (Fig. 3) is valued with five answers on Likert scale. Operators employed in CF Ltd. believe that fatigue significantly (very much – 41.03%) affects the quality and productivity of the work compared to those employed by the private contractor (17.86%). Higher percentage of the rates »much«, »medium« and »little« is recorded by the operators employed in the private forestry sector (Fig. 3).

Jobs with an increased risk, especially for the development of work-related diseases, require medical

**Table 4** Rating of organizational factors during work of machine operators (answer share, %)
***Tablica 4.*** *Ocjena organizacijskih čimbenika u radu rukovatelja mehanizacijom (udio odgovora, %)*

| Organizational factors – *Organizacijski čimbenici* | Croatian Forests Ltd. *Hrvatske šume d.o.o.* | | | Private forest company *Privatna šumarska tvrtka* | | |
|---|---|---|---|---|---|---|
| | Yes – *Da* | No – *Ne* | Don't know Ne znam | Yes – Da | No – Ne | Don't know Ne znam |
| Work techniques training in mechanized timber extraction *Osposobljavanje radnim tehnikama pri mehaniziranom privlačenju* | 48.72 | 38.46 | 12.82 | 78.57 | 14.29 | 7.14 |
| Exposure to excessive noise and vibration *Izloženost prekomjernoj buci i vibracijama* | 41.03 | 25.64 | 33.33 | 32.14 | 39.29 | 28.57 |
| All PPE provided – *Osiguranost svih OZS* | 94.87 | 5.13 | 0.00 | 64.29 | 32.14 | 3.57 |
| Ful use of PPE – *Uporaba OZS u punoj mjeri* | 53.85 | 43.59 | 2.56 | 50.00 | 50.00 | 0.00 |
| First-aid kit and fire extinguisher in the machine *Kutija prve pomoći i protupožarni aparat u stroju* | 97.44 | 2.56 | 0.00 | 85.71 | 14.29 | 0.00 |
| Appearance of pain and discomfort caused by body position at work *Pojava boli i neugode uzrokovana položajem tijela pri radu* | 58.97 | 41.03 | 0.00 | 50.00 | 42.86 | 7.14 |

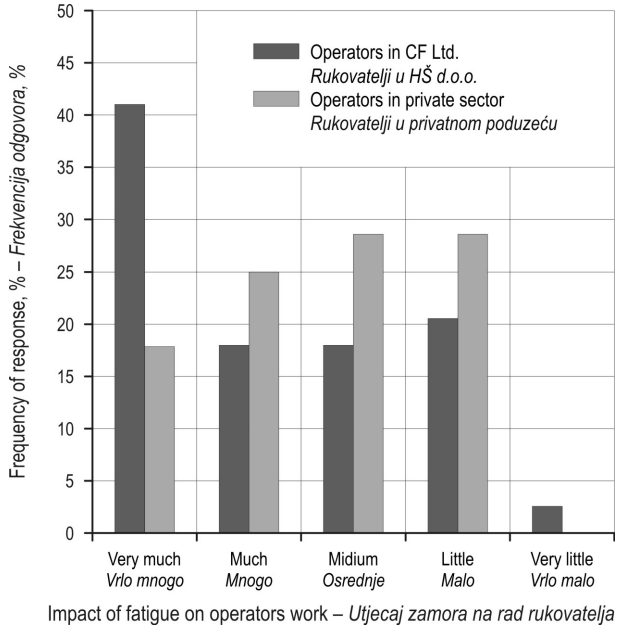


**Fig. 3** Rating the impact of fatigue on the quality and productivity of machine operator work
***Slika 3.*** *Ocjena utjecaja zamora na vrsnoću i proizvodnost rukovatelja mehanizacijom*

supervision of employees for early detection, monitoring and treatment of health disorders partially caused by exposure to physical and mental challenge, and hazards at work (Macan et al. 2012). As part of the research, the symptoms of headache were noticed by 17 participants, and the appearance of symptoms of insomnia was noted by 11 participants employed by the company CF Ltd. A high proportion of respondents said that the symptoms of headache were associated with work (Table 5). A smaller percentage of respondents employed by private contractors reported the appearance of symptoms, but they put the emphasis on the connection between these symptoms and the daily work activities and demands at work (Table 5).

#### 4.2.3 Impact of psychological and social factors on forestry machine operators – *Utjecaj psihološko društvenih čimbenika na rukovatelje šumarskom mehanizacijom*

Psychological and social factors of the working environment may have a direct impact on the health and safety of forest machine operators, as well as on productivity. One of the most important tasks of employers is to keep the mental load and strain of employees at acceptable levels, all with the long-term goal of diminishing the probability of occurrence and development of mental stress (Landekić et al. 2011a). According to the rating of mental job demands by forestry machine operators (Fig. 4), the results show a significant proportion of large and very large (46.42%) mental demands of the job performed by operators employed in private companies in relation to the operators employed in the state–owned company CF Ltd.

The reason for the increased mental demands of the job indicated by the operators employed in a pri-

**Table 5** Headaches and insomnia symptoms experienced by forestry machine operators
***Tablica 5.*** *Pojava simptoma glavobolje i nesanice kod rukovatelja mehanizacijom u šumarstvu*

| Croatian Forests Ltd. – *Hrvatske šume d.o.o.* | | | | Private forest company – *Privatna šumarska tvrtka* | | | |
|---|---|---|---|---|---|---|---|
| Headache – *Glavobolja* | | Insomnia – *Poremećaj spavanja* | | Headache – *Glavobolja* | | Insomnia – *Poremećaj spavanja* | |
| 17 respondents (43.59%)<br>*17 ispitanika (43,59 %)* | | 11 respondents (28.21%)<br>*11 ispitanika (28,21 %)* | | 10 respondents (35.71%)<br>*10 ispitanika (35,71 %)* | | 5 respondents (17.86%)<br>*5 ispitanika (17,86 %)* | |
| Work–related<br>*Povezano s poslom* | | Work–related<br>*Povezano s poslom* | | Work–related<br>*Povezano s poslom* | | Work–related<br>*Povezano s poslom* | |
| Yes – *Da* | No – *Ne* | Yes – *Da* | No – *Ne* | Yes – *Da* | No – *Ne* | Yes – *Da* | No – *Ne* |
| 70.59% | 29.41% | 45.46% | 54.54% | 70.00% | 30.00% | 60.00% | 40.00% |

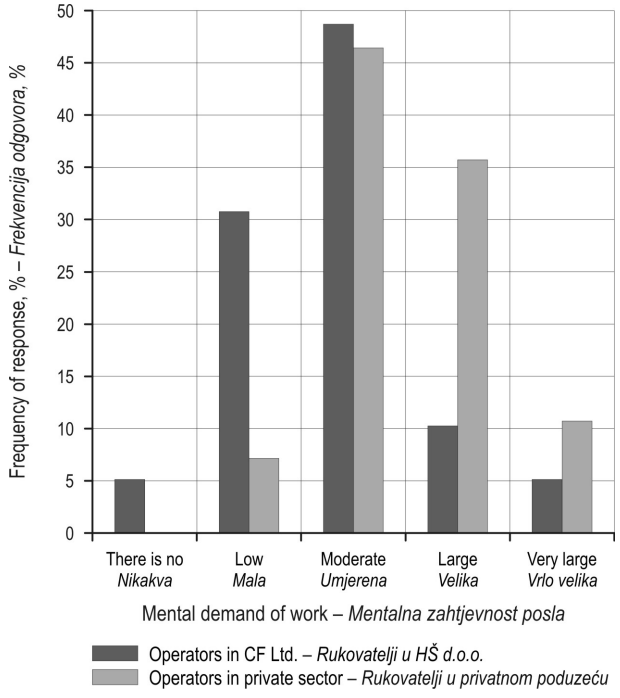


**Fig. 4** Rating of job mental demands by forestry machine operators
***Slika 4.*** *Ocjena mentalne zahtjevnosti posla kod rukovatelja šumarskom mehanizacijom*

vate company (Fig. 4) can be partially linked with the results in Table 6 related to time pressure, working climate, acquiring new skills or knowledge and some other factors of the working environment explored in this paper. Relative frequency of responses related to time pressure at work is presented in Table 6. The percentage share of responses shows a greater presence of time pressure at work for operators employed in a private company (often or always – 32.14%). Evaluation of acquiring new skills or knowledge (Table 6) resulted in almost equal frequency response of forest workers employed in the private sector and in CF Ltd. Influence of the working climate within the operators' working environment, expressed through business solidarity, working atmosphere, good relationship with superiors and colleagues, is evaluated in Table 6. The results show a higher proportion of affirmative answers (often and always) on the subject of freedom to make own decisions while working and the existence of a sense of solidarity by the operators employed in private companies. On the other hand, a greater proportion of affirmative answers (often or always) were recorded by operators employed in CF Ltd. regarding good working atmosphere and good relationship with superiors and colleagues (Table 6).

### 4.3 Work Ability Index of Forestry Machine Operators – *Indeks radne spremnosti rukovatelja šumarskom mehanizacijom*

Work ability index is a tool in the form of a questionnaire used for the self-assessment of employees. Focus is put on employees and their job readiness in relation to the requirements of their current job position. It also highlights the need to adapt working conditions to the capacities and capabilities of employees. Mean score of the work ability index of machine operators, employed in Croatian forests Ltd. and in private companies, is shown in Table 7. The results of the WAI average score show a negligible difference between the operators employed in the private sector and in state forestry sector. They have good work ability (score 37–43), which should be kept at the existing level.

For a more detailed insight into work ability, a thorough examination of opinions and attitudes of forestry machine operators included as follows: (a) correlation analysis of work ability index (WAI) with

**Table 6** Evaluation of some psychological and social factors of the working environment, %
***Tablica 6.*** *Procjena nekih psihološko-društvenih čimbenika radnoga okoliša, %*

| Questions – *Pitanja* | Croatian Forests Ltd. *Hrvatske šume d.o.o.* | | | | Private forest company *Privatna šumarska tvrtka* | | | |
|---|---|---|---|---|---|---|---|---|
| | Never *Nikad* | Rarely *Rijetko* | Often *Često* | Always *Uvijek* | Never *Nikad* | Rarely *Rijetko* | Often *Često* | Always *Uvijek* |
| Do you feel the time pressure due to the volume of work? *Osjećate li vremenski pritisak zbog opsega posla?* | 20.51 | 66.67 | 12.82 | 0.00 | 17.86 | 50.00 | 21.43 | 10.71 |
| Do you learn new things at work? *Učite li nove stvari na poslu?* | 10.26 | 33.33 | 35.90 | 20.51 | 0.00 | 32.14 | 42.86 | 25.00 |
| Does your job require skills? *Zahtijeva li Vaš posao vještinu?* | 2.56 | 23.08 | 74.36 | 0.00 | 17.86 | 21.43 | 53.57 | 7.14 |
| Does your job require ingenuity? *Zahtijeva li Vaš posao domišljatost?* | 2.56 | 2.56 | 38.46 | 33.33 | 0.00 | 28.57 | 25.00 | 46.43 |
| Do you have any freedom to decide at work? *Imate li slobodu odlučivanja u radu?* | 5.13 | 25.64 | 41.03 | 30.77 | 10.71 | 17.86 | 35.71 | 35.71 |
| Is the atmosphere at work pleasant? *Je li atmosfera na poslu ugodna?* | 0.00 | 10.26 | 43.59 | 46.15 | 0.00 | 10.71 | 50.00 | 39.29 |
| Is there a sense of solidarity? *Postoji li osjećaj solidarnosti?* | 2.56 | 12.82 | 33.33 | 51.28 | 0.00 | 7.14 | 67.86 | 25.00 |
| I have a good relationship with my superiors? *Slažete li se dobro s nadređenim?* | 0.00 | 2.56 | 25.64 | 71.79 | 0.00 | 3.57 | 42.86 | 53.57 |
| I have a good relationship with my colleagues? *Slažete li se dobro s kolegama?* | 0.00 | 0.00 | 17.95 | 82.05 | 0.00 | 3.57 | 46.43 | 50.00 |

**Table 7** Work ability index of forestry machine operators – CF Ltd. and private contractors
***Tablica 7.*** *Indeks radne spremnosti rukovatelja šumarskom mehanizacijom – HŠ d.o.o. i privatni izvoditelji*

| Indicator *Pokazatelj* | Number of operators *Broj rukovatelja* | Minimum *Minimum* | Maximum *Maksimum* | Arithmetic mean *Aritmetička sredina* | Standard deviation *Standardna devijacija* |
|---|---|---|---|---|---|
| WAI (CF Ltd.) *IRS (HŠ d.o.o.)* | 39 | 24.00 | 49.00 | 38.46 | 5.70 |
| WAI (private contractors) *IRS (privatni izvoditelji)* | 28 | 24.00 | 48.00 | 38.11 | 5.39 |

demographic indicators of the respondents and (b) testing the WAI difference among a group of descriptive variables.

#### 4.3.1 Correlation of work ability index and demographic parameters of respondents – *Mjere povezanosti indeksa radne spremnosti i demografskih parametara ispitanika*

This section shows testing the strength and direction of respondent demographic parameters and work ability index. Correlation and influence are reviewed with the aim of gaining a more comprehensive understanding of the relation between the work of forestry machine operators and their functional ability (WAI) depending on work experience, age and weight of the workers. *Spearman's* rank correlation coefficient was used to assess the degree and direction of the relation between the derived indicators.

The indicator of machine operator work ability index negatively correlated with three demographic

**Table 8** Rank correlation of work ability index of machine operators and demographic parameters
***Tablica 8.*** *Korelacija ranga indeksa radne spremnosti i demografskih parametara rukovatelja mehanizacijom*

| Variable<br>*Varijabla* | Indicator<br>*Pokazatelj* | Age<br>*Godine života* | Mass<br>*Masa* | Work experience in forestry<br>*Radno iskustvo u šumarstvu* | Work ability index<br>*Indeks radne spremnosti* |
|---|---|---|---|---|---|
| Age<br>*Godine života* | $r_s$ | 1.000 | 0.238 | 0.769** | –0.525** |
| | *p* | – | 0.052 | 0.000 | 0.000 |
| Mass<br>*Masa* | $r_s$ | 0.238 | 1.000 | 0.335** | –0.247* |
| | *p* | 0.052 | – | 0.006 | 0.044 |
| Work experience in forestry<br>*Radno iskustvo u šumarstvu* | $r_s$ | 0.769** | 0.335** | 1.000 | –0.443** |
| | *p* | 0.000 | 0.006 | – | 0.000 |
| Work ability index<br>*Indeks radne spremnosti* | $r_s$ | –0.525** | –0.247* | –0.443** | 1.000 |
| | *p* | 0.000 | 0.044 | 0.000 | – |

* Correlation is significant at the 0.05 – *Korelacija je značajna na razini 0,05;* ** Correlation is significant at the 0.01 – *Korelacija je značajna na razini 0,01*

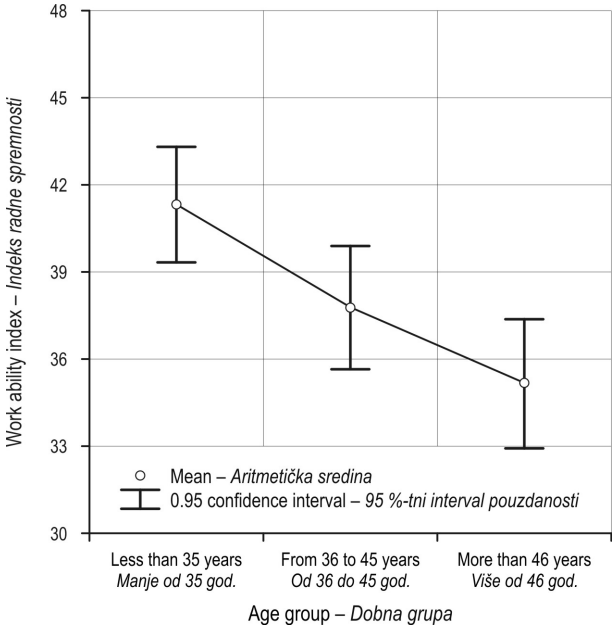


**Fig. 5** Mean value of WAI by three age groups
***Slika 5.*** *Srednja vrijednost IRS prema trima dobnim grupama*

variables. The relationship of work ability index and age of the respondents resulted in a strong negative correlation (Table 8), $r = -0.525$; $n = 67$; $p<0.01$, where a high level of work ability index was recorded with younger machine operators. The calculated coefficient of determination ($r^2 = 0.275$) showed that age accounted for 25.5% of the variance in the respondents answers regarding the indicator of work and functional ability. Strength and direction of relationship between the work ability index and work experience in forestry was medium negative ($r = -0.443$; $n = 67$; $p<0.01$), where a higher level of work ability index was recorded with machine operators with less experience in forestry, and the calculated coefficient of determination ($r^2 = 0.196$) indicated that work experience accounted for 19.6% of the variance in the respondents answers regarding the indicator of work and functional ability. The relation between the work ability index of machine operators and the mass of respondents resulted in a small negative correlation ($r = -0.2474$; $n = 67$; $p<0.05$).

### 4.3.2 Testing the diference of WAI between groups of descriptive variables – *Ispitivanje razlika indeksa radne spremnosti prema opisnim varijablama*

Using the database of respondents, differences were tested between the work ability index and selected descriptive variables. The following descriptive variables were used: a) age group and b) group of work experience in forestry. The homogeneity of variance between groups of data was tested with *Levene's test* ($p>0.05$), where on the basis of test significance level a further testing of WAI difference was conducted with parametric and/or nonparametric techniques.

Due to inadequacy of variance homogeneity, alternative nonparametric analysis of variance (Kruskal–Wallisov test) was used to test the difference of work ability index among three groups of respondents according to age. Also, differences in work ability index were examined between the four groups of respondents regarding work experience in forestry.

**Table 9** Testing the difference between WAI groups using the Kruskal–Wallis *H* test
***Tablica 9.*** *Ispitivanje razlika IRS između grupa pomoću Kruskal–Wallisova* H-*testa*

| Descriptive variable – *Opisne varijable* | Chi-square *Hi-kvadrat* | Degrees of freedom *Stupnjevi slobode* | Sample size *Veličina uzorka* | *P*-value P-*vrijednost* |
|---|---|---|---|---|
| Age of respondents – *Godine života* | 16.897 | 2 | 67 | 0.000** |
| Work experience in forestry – *Radno iskustvo u šumarstvu* | 14.776 | 3 | 67 | 0.002** |

** The difference is significant at 0.01 – *Razlika je značajna na razini 0,01*

Groups by age:
⇒ group 1: less than 35 years of age;
⇒ group 2: from 36 to 45 years of age;
⇒ group 3: more than 46 years of age;

Groups by work experience in forestry:
⇒ group 1: 0–10 years of work experience;
⇒ group 2: 11–20 years of work experience;
⇒ group 3: 21–30 years of work experience;
⇒ group 4: 31–40 years of work experience.

Testing the score values of work ability index among defined groups of respondents resulted in the following statistically significant differences (Table 9).

Statistically significant difference was determined among the age groups ($p$<0.01), where operators with less than 35 years of age have the highest level of work ability index (median – *M*d = 41.00) compared to their older colleagues (Fig. 5). Subsequent testing of the difference using the *Mann-Whitney U test* showed that the median value of WAI in group 1 (<35 years) (*M*d = 41.00, $N$ = 25) was significantly different from group 3 (>46 years of age) (*M*d = 35.50, $N$ = 20), $U$ = 64.50; $z$ = -4.255; $p$ = 0.000. A statistically significant difference was not confirmed between group 2 and group 1. Forestry machine operators with more than 46 years of age employed in the state sector (CF Ltd) showed a significantly better working and functional ability in relation to operators working in the private forestry sector (Fig. 6).

Forestry machine operators with less than 10 years of experience in forestry had the highest level of work

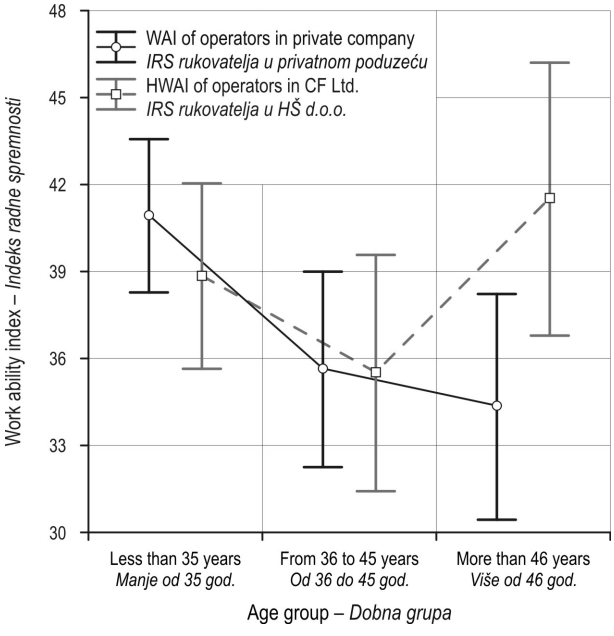


**Fig. 6** WAI of machine operators in private and public sector by age groups
***Slika 6.*** *IRS rukovatelja mehanizacijom u privatnom i državnom sektoru prema dobnim grupama*

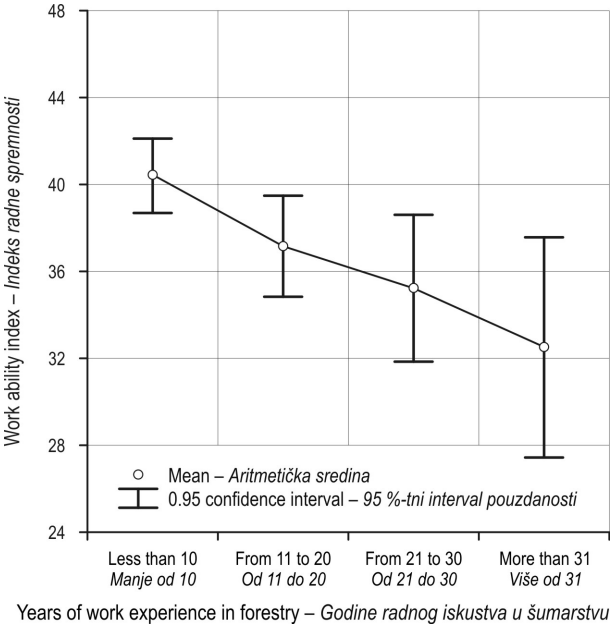


**Fig. 7** Mean value of WAI by four groups of working experience in forestry
***Slika 7.*** *Srednja vrijednost IRS prema četirima grupama radnoga staža u šumarstvu*

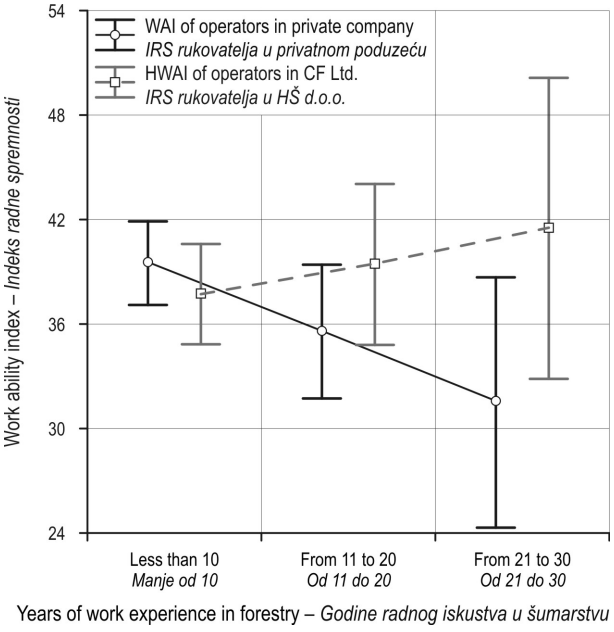


**Fig. 8** WAI of machine operators in private and public sector by groups of work experience

***Slika 8.*** *IRS rukovatelja mehanizacijom u privatnom i državnom sektoru prema grupama radnoga staža*

ability index (*M*d = 41.00) in comparison to colleagues with more years of experience (Fig. 7). Using the *Mann-Whitney U test*, testing of differences showed that the median value of WAI in group 1 (<10 years of service) (*M*d = 41.00; *N* = 35) was significantly different from group 2 (*M*d = 37.00; *n* = 19) *U* = 196.50; *z* = –2.473; *p* = 0.013, group 3 (*M*d = 33.00; *N* = 8) *U* = 65.00; *z* = –2.704; *p* = 0.007 and group 4 (>31 years of service) (*M*d = 34.00; *N* = 4) *U* = 15.500; *z* = -2.238; *p* = 0.011. The research has also shown that the indicator of employees work ability in the state sector slightly increases with years of service, while in the private sector it declines with years of service (Fig. 8).

## 5. Discussion and conclusions – *Rasprava i zaključci*

The study was designed with the purpose of determining the limits of forestry machine operators' working and functional ability and acquiring insights in some ergonomic aspects of their working environment in forestry production. The investigated education level of machine operators showed a lack of specialized education. In an effort to overcome the weaknesses of the national training system, the Croatian forestry sector needs to look at examples of good practices implemented by the European countries, and at measures advocated by Martinić et al. (2011), regarding the establishment of a national center for forestry, which would enable the implementation of the certification process of machine operator training in forestry. Also, it is necessary to develop the safety culture in the forestry sector through the development of personal responsibility for the safety, use of personal protective equipment and establishment of joint responsibility on safety including the management and employees.

Psychological and social aspects of the working environment of machine operators resulted in a higher level of mental demands on the job with the operators employed in private forest companies. A higher proportion of time pressure due to the volume of work and poor working climate in the workplace of operators employed in the private forestry sector goes in favor of the obtained results on mental demand. Psychological and social factors of the working environment can influence the operators' productivity, and therefore one of the most important tasks of employers is to keep the mental load and strain of employees at acceptable levels (Landekić et al. 2011a).

Demographic parameters of the respondents (age, work experience in forestry and weight) negatively affect the working and functional ability (WAI) of forestry machine operators. Machine operators with less than 35 years of age and with less than 10 years of experience in forestry have the highest level of work ability index, which is significantly different ($p$<0.01) from the WAI in the oldest groups. Lower work ability of the respondends in the oldest group, according to Ilmarinen at al. (2005), can be related to the health (symptoms) and functional capacity (physical) or work factors (mental strain) at the workplace of machine operators. According to age groups, machine operators working in private companies, with more than 46 years of age, have a considerably lower WAI compared to operators employed by the company CF Ltd. Also, within the groups formed by work experience in forestry, a visible reduction in the level of WAI (moderate rating) is observed with operators working in private companies, which indicates the need for measures required to improve the current situation. The responses of all machine operators and the analysis presented in this paper represent an important contribution in the process of developing a model of security measures for the improvement of health and safety system in timber extraction through education on work ability index and responsibilities that need to be implemented in private and state forestry sector. Such approach helps to identify potential work-related health risks in order to implement appropriate

measures aimed at reducing the possibility of declining the working capacity of employees and preventing their early retirement. Maintenance and/or improvement of the working and functional ability of forestry machine operators can and needs to be carried out through periodical training during the whole working life.

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## Sažetak

### *Indeks radne spremnosti rukovateljâ šumarskom mehanizacijom i neki ergonomski aspekti njihova rada*

*U radu se analiziraju neki ergonomski aspekti radnoga okoliša te se numerički vrednuje radna spremnost rukovateljâ šumarskom mehanizacijom kao prvi korak u ocjeni trenutačnoga stanja. Pritom je metodom anketiranja tijekom 2012. godine istražen i analiziran a) indeks radne spremnosti (eng. Work Ability Index) (tablica 1) te b) ergonomski aspekt radnoga mjesta rukovateljâ šumarskom mehanizacijom za državni (Hrvatske šume d.o.o.) i privatni šumarski sektor.*

*Prvi dio rezultata obuhvaća a) profil ispitanika (tablica 2), b) organizaciju rada rukovateljâ mehanizacijom i njihovo obrazovanje (tablica 3 i 4), c) utjecaj umora (slika 3) i d) utjecaj psiholoških i socijalnih čimbenika na radnu sposobnost rukovateljâ (slika 4). Na temelju nalaza istraživanja prikazanih u radu potvrdilo se da se u šumarskom sektoru Republike Hrvatske, kako u državnom tako i u privatnom, vrlo malo sredstava, znanja i truda ulaže u osposobljavanje, sigurnost i zdravlje radnika. Prevladavaju nekvalificirani radnici (tablica 3) koji upravljaju vrlo skupim strojevima bez osnovnoga strukovnoga i specijalističkoga obrazovanja. Razlog je tomu nepostojanje zakonskih instrumenata u smislu obvezne certifikacije znanja i vještina za rukovatelje šumarskom mehanizacijom u RH, a posljedično i manjak organizacije pratećega sustava certifikacije. Također, rezultati istraživanja pokazuju da zaposlenici nisu obrazovani kako izvoditi radove uza što manje fizičkoga i psihičkoga opterećenja (slika 3 i 4), te kako postići optimalnu dinamiku dnevnoga rada u pogledu održavanja tjelesne kondicije, koncentracije i dr. Radnicima koji upravljaju šumarskim strojevima u većini slučajeva osigurana su propisana osobna zaštitna sredstva, ali većina ih se ne koristi njima ili se koriste njima na neispravan način (tablica 4). Drugi dio rezultata vezan uz numeričko vrednovanje radne spremnosti rukovateljâ obuhvaća a) odnos radne spremnosti rukovateljâ prema demografskim kategorijama ispitanika (tablica 7 i 8) i b) pregled razlika između indeksa radne spremnosti prema odabranim opisnim varijablama (slika 5, 6, 7 i 8). Ključni parametri ispitanika (godine života, radno iskustvo u šumarstvu, masa ispitanika) negativno utječu na radnu i funkcionalnu spremnost (IRS) rukovateljâ šumarskom mehanizacijom (tablica 8). Rukovatelji mehanizacijom zaposleni u privatnom sektoru s više od 46 godina života imaju zamjetno niži IRS u usporedbi s rukovateljima zaposlenim u HŠ d.o.o. (slika 5 i 6). Također, unutar grupa prema radnomu iskustvu vidljivo je smanjenje vrijednosti IRS (srednje bodovano) te su potrebne mjere za unapređenje postojećega stanja (slika 7 i 8).*

*Zaključno, na temelju rezultata dani su prijedlozi za unapređenje istraživanih čimbenika radne spremnosti rukovateljâ šumarskom mehanizacijom. Kao nužna mjera poboljšanja potreban je cjelovit i kvalitetan postupak osposobljavanja kojim će se rukovatelji šumarskom mehanizacijom upoznati s opasnostima i štetnostima u procesu privlačenja drveta, s vrstama i razinom opterećenja pri radu te osposobiti za rad uporabom sigurnoga načina rada i optimalne radne tehnike. Samo korektni radni postupci povezani sa zadovoljavajućom razinom radne sposobnosti mogu preduhitriti nastanak tjelesnih ozljeda i zdravstvenih tegoba rukovateljâ. U nastojanju da se riješe slabosti državnoga sustava obuke radnika, hrvatsko se šumarstvo treba ugledati na primjere dobre prakse iz zemalja u europskom okruženju, a prema modelu Martinića i suradnika (2011) sa središnjom ulogom nacionalnoga centra za šumarstvo rada koji bi po svom osnutku trebao biti središte sustava za provedbu procesa certificiranja rukovatelja mehanizacijom u šumarstvu*

*Ključne riječi: šumarstvo, rukovatelji mehanizacijom, indeks radne spremnosti, radni okoliš*

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