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Effects of Work Types and Workload on Certain Anthropometric Parameters in Forestry Workers

Habip Eroglu[1*], Yildirim Kayacan[2] and Rahmi Yilmaz[3]

[1]Department of Forest Engineering, Karadeniz Technical University, 61080, Trabzon, Turkey
E-mail: habip@ktu.edu.tr
[2]Faculty of Yasar Dogu Sport Science, Ondokuz Mayis University, 55139 Samsun, Turkey
E-mail: kayacan@gmail.com
[3]Department of Forest Engineering, Artvin Çoruh University, 08000, Artvin, Turkey
E-mail: rahmiyilmaz84@hotmail.com

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ABSTRACT Using computer software and anthropometric measurements, the present study analyzes the changes in body posture associated with the workload exposure of harvesting and nursery-afforestation workers. Studies were conducted in 10 different locations within the boundaries of the Regional Directorate of Forestry (RDF) in Artvin, Turkey. A total of 88 male forestry workers (32 harvesting and 56 nursery-afforestation worker) aged between 18 and 61 years, were assessed in the study. Forestry activities are associated with an intense deformation in the upper extremities, having a detrimental effect on anthropometric parameters and the development of an abnormal posture, which results from intense stress on the muscles and other tissues with increasing workload. This effect was found to be more severe among the harvesting workers when compared to the nursery-afforestation workers.

INTRODUCTION

The forestry sector is known as a labor-intensive form of employment involving different types of activities, which inevitably compel the employee to work outdoors (Eroglu et al. 2008). The forestry profession requires both, static and dynamic muscle power, since it imposes hard labor of intense loads on the musculoskeletal system of forestry workers (Bovenzi et al. 2004; Yovi and Yamada 2015).

The Ovako Working Posture Analyzing System (OWAS), Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) are used in the analysis of working positions (Kee and Karwowski 2007; Pandey and Vats 2012; Roman-Liu 2015), while the postural characteristics of individuals are analyzed to determine nutritional and developmental problems in terms of human health (Maslen and Straker 2009; Widhe et al. 2001; Mialich et al. 2014) in order to determine working performance in the field of ergonomics (Bao et al. 2007; Holden et al. 2015), and to increase performance in sports (Lien 2005; Momaya et al. 2015; Alexander et al. 2015).

The risk of disability after sustaining head, shoulder, back and low-back injuries is extremely high, and the associated health problems are considerably common among workers employed in heavy industries (Miranda et al. 2001; Coggon et al. 2013; Quandt et al. 2013). Taking an inappropriate posture while working imposes intense load on the joints and can lead to injuries of tissue, muscles and ligaments (Tüzün et al. 1999; Cavanaugh et al. 2015). The kyphotic posture while working at ground level constitutes a health risk to the workers, which can lead to the development of musculoskeletal problems (Wong et al. 2009).

An asymmetric body position subjects the muscles, bones and other structures to excessive activities, and results in significant problems (Karakus and Kilinc 2006; Strini et al. 2014). In addition, an inappropriate posture can lead to a mechanical stretching of the central nervous system, which may result in various anatomical problems (Harrison et al. 2007; Arial et al. 2014).

In the present study, the changes in posture associated with working in the harvesting and nursery-afforestation in the forestry sector, were analyzed using computer software and anthropometric measurements. To this end, postural

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Address for correspondence:
Dr. Yildirim Kayacan
Faculty of Yasar Dogu Sport Science,
Ondokuz Mayis University, 55139 Samsun, Turkey
Telephone: + 90 319 19 19
E-mail: kayacan@gmail.com

changes according to BMI and working time of workers selected from different working fields were evaluated in this study.

MATERIAL AND METHODS

Within the scope of this research, studies were conducted in 10 spots, all of which were located within the boundaries of RDF (Regional Directorate of Forestry), Artvin, Turkey (Fig. 1). The study was conducted on 88 male forestry workers, all of whom were males aged between 18 and 61. Among them, 32 were employed in the harvesting area, while 56 were employed in the nursery-afforestation area.

The harvesting workers performed such tasks as tree cutting, branch collecting, peeling, logging, cabling to the nearest roadside and wood extraction with cabled overhead lines. The nursery-afforestation workers performed such activities as preparing seedbeds, filling of tubes and placing them in harvesting parcels, disinfecting them from pests, shelling, harvesting, sapling packaging, and sowing. The afforestation workers performed their tasks in the afforestation activity as applied in the slope stabilization.

As a part of the study, the anthropometrical characteristics of the workers were first identified. After identifying the workers' age, sex, height and weight, coloured markers were placed on the reference points on the body, photos were taken from an anterior and lateral perspective on a platform on flat ground and transferred to the Posture Analysis (tm 2003) software. During the measurements, real time control of the measurements taken with anthropometrical set was ensured. While taking the BMI values of the participant into consideration, anterior and sagittal balance, general standing posture and the angular relationship between the extremities were identified while some upper extremities were analyzed. A healthy standard posture was taken as a reference point in the posture analysis. Angular values were expressed as an "angle" (p) while distance and length were expressed as "cm".

Reference points used in the posture analysis are, glabella, chin, acromion process, episternal notch, anterior superior iliac spine (ASIS),

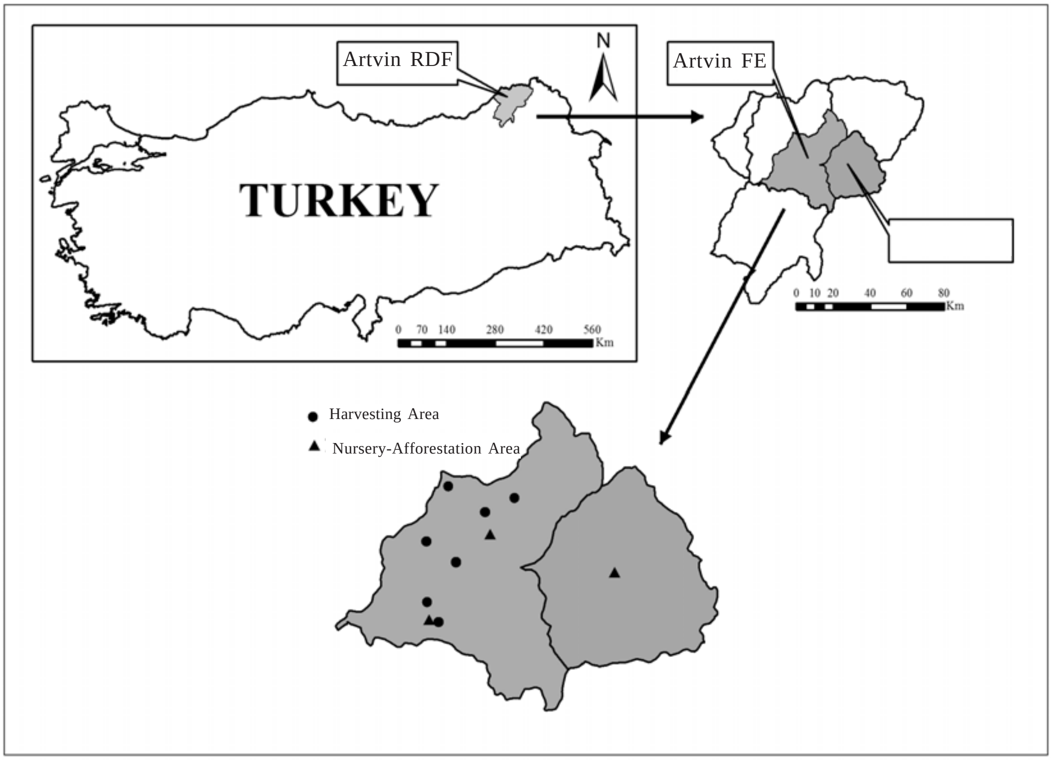

Fig 1. The location of the study sites

patella, mortise (anterior), ear canal, posterior superior iliac spine (PSIS), greater trochanter, lateral femoral condyle and lateral malleolus (Alves et al. 2010; Eroglu et al. 2013; Kayacan et al. 2014).

Seventeen (17) parameters investigated in posture analysis were,

1. Angle of lateral head deviation (Anterior-Left),
2. Angle of lateral head deviation (Anterior-Right),
3. Angle of backward head posture (Sagittal),
4. Angle of forward head posture (Sagittal),
5. Distance of head posture from acromion process (Sagittal),
6. Angle between the left acromion processes (Anterior),
7. Angle between the right acromion processes (Anterior),
8. Horizontal distance from acromion process to plumb line (Sagittal-Left),
9. Horizontal distance from acromion process to plumb line (Sagittal-Right),
10. Horizontal distance from sternal notch to the plumb line (Anterior-Left),
11. Horizontal distance from sternal notch to the plumb line (Anterior-Right),
12. Height of the acromion process from sternal notch (Anterior-Left),
13. Height of the acromion process from sternal notch (Anterior-Right),
14. Middle of the acromion processes to the plumb line (Anterior-Left),
15. Middle of the acromion processes to the plumb line (Anterior-Right),
16. Angle of the clavicles (Anterior-Left) and,
17. Angle of the clavicles (Anterior-Right) (°).

Body Mass Index (BMI) and working experience of workers were used to compare statistical postur properties of nursery-afforestation and harvesting workers. The values of BMI were calculated according to formula 1 (Kirk and Sullman 2001).

$BMI = kg / m^2$ (formula 1)

BMI values of workers were classified according to Table 1 (Kirk and Sullman 2001). SPSS 19.0 software was used for statistical analysis. Independent sample t-test was applied to determine the differences between nursery-afforestation and harvesting workers. A "One Way Anova" analysis of variance was used to identify the differences between groups according to BMI values and working experiences of nursery-afforestation and harvesting workers. P <0.05 value was considered to be statistically significant.

Table 1: Clasification of BMI values

Groups	*BMI values*	*Class*
1	< 25	Thin
2	25-29.9	Normal
3	30 <	Fat

RESULTS

The mean age of nursery-afforestation and harvesting workers was 46±3.4 and 45±2.1 years, respectively. The mean duration of employment was 19.64±3.8 years among the harvesting workers and 15.41±4.2 years among those involved in nursery-afforestation.

The mean values obtained from anthropometric measurements are presented in Table 2, which reveals that the angle of lateral head deviation (Ant-L) (°), distance of head posture from acromion process (Sag) (cm), angle between the right acromion process (Ant) (°), horizontal distance from acromion process to plumb line (Sag-R) (cm), height of the acromion process from sternal notch (Ant-R) (cm), and angle of the clavicles (Ant-L) (°) were lower, while other parameters were higher in nursery-afforestation workers when compared to harvesting workers.

A statistical analysis of the postural parameters of the upper extremities revealed significant differences between nursery-afforestation workers and those engaged in harvesting in terms of the angle of lateral head deviation (Ant-L) (°), angle of lateral head deviation (Ant-R) (°), angle between the left acromion processes (Ant) (°), angle between the right acromion processes (Ant) (°), horizontal distance from acromion process to plumb line (Sag-L) (cm), horizontal distance from sternal notch to the plumb line (Ant-R) (cm), middle of the acromion processes to the plumb line (Ant-R) (cm) and angle of the clavicles (Ant-R) (°) (P<0.05). The F values and Sig. values pertaining to these differences are presented in Table 3.

The mean BMI of nursery-afforestation and harvesting workers is 26.96±2.1 kg and 25.94±1.9 kg, respectively (Table 4).

The analysis of the variance in BMI values of the nursery-afforestation workers and harvesting workers revealed significant differences between Group 1 (BMI<20) and Group 2 (25<BMI <30) among the harvesting workers in terms of

Table 2: Mean values of the postural parameters measured in the workers

Postural parameters	*Average values*	
	Nursery-afforestation	*Harvesting*
Angle of Lateral Head Deviation (Ant-L) (°)	0.94	1.75
Angle of Lateral Head Deviation (Ant-R) (°)	1.81	0.91
Angle of Backward Head Posture (Sag) (°)	1.28	0.62
Angle of Forward Head Posture (Sag) (°)	11.84	12.57
Distance of Head Posture from Acromion Process (Sag) (cm)	3.91	4.04
Angle between the Left Acromion Processes (Ant) (°)	1.81	1.36
Angle between the Right Acromion Processes (Ant) (°)	0.81	0.91
Horizontal Distance from Acromion Process to Plumb Line (Sag-L) (cm)	0.49	0.14
Horizontal Distance from Acromion Process to Plumb Line (Sag-R) (cm)	3.42	3.90
Horizontal Distance from Sternal Notch to the Plumb Line (Ant-L) (cm)	0.64	0.38
Horizontal Distance from Sternal Notch to the Plumb Line (Ant-R) (cm)	0.77	0.41
Height of the Acromion Process from Sternal Notch (Ant-L) (cm)	2.14	2.12
Height of the Acromion Process from Sternal Notch (Ant-R) (cm)	1.58	1.83
Middle of the Acromion Processes to the Plumb Line (Ant-L) (cm)	0.49	0.28
Middle of the Acromion Processes to the Plumb Line (Ant-R) (cm)	1.00	0.59
Angle of the Clavicles (Ant-L) (°)	4.53	9.82
Angle of the Clavicles (Ant-R) (°)	7.44	4.64

Ant-L: Anterior Left, Ant-R: Anterior Right, Sag-L: Sagittal Left, Sag-R: Sagittal Right

Table 3: Values of independent sample t-test for the differences between harvesting and nursery-afforestation workers

Postural parameters	*t-test for equality of means*	
	F	*Sig.*
Angle of Lateral Head Deviation (Ant-L) (°)	6.450	0.040*
Angle of Lateral Head Deviation (Ant-R) (°)	10.204	0.046*
Angle of Backward Head Posture (Sag) (°)	5.375	0.251
Angle of Forward Head Posture (Sag) (°)	0.679	0.692
Distance of Head Posture from Acromion Process (Sag) (cm)	0.103	0.802
Angle between the Left Acromion Processes (Ant) (°)	0.487	0.031*
Angle between the Right Acromion Processes (Ant) (°)	0.042	0.045*
Horizontal Distance from Acromion Process to Plumb Line (Sag-L) (cm)	17.542	0.048*
Horizontal Distance from Acromion Process to Plumb Line (Sag-R) (cm)	0.483	0.395
Horizontal Distance from Sternal Notch to the Plumb Line (Ant-L) (cm)	2.326	0.307
Horizontal Distance from Sternal Notch to the Plumb Line (Ant-R) (cm)	3.277	0.041*
Height of the Acromion Process from Sternal Notch (Ant-L) (cm)	0.061	0.946
Height of the Acromion Process from Sternal Notch (Ant-R) (cm)	0.118	0.463
Middle of the Acromion Processes to the Plumb Line (Ant-L) (cm)	2.535	0.384
Middle of the Acromion Processes to the Plumb Line (Ant-R) (cm)	11.409	0.044*
Angle of the Clavicles (Ant-L) (°)	0.010	0.836
Angle of the Clavicles (Ant-R) (°)	0.924	0.029*

Ant-L: Anterior Left, Ant-R: Anterior Right, Sag-L: Sagittal Left, Sag-R: Sagittal Right

the angle between the left acromion process (Ant) (°), angle between the right acromion process (Ant) (°) and horizontal distance from sternal notch to the plumb line (Ant-R) (cm) ($p<0.05$).

There are also significant differences between Group 3 (BMI>30) and Group 2 (25 <BMI <30) among harvesting workers in terms of the angle of forward head posture (Sag) (°), horizontal distance from acromion process to plumb line (Sag-R) (cm), height of the acromion process from

Table 4: Body mass index values of workers

Work types	*Body mass index values (kg)*
Nursery-Afforestation	26.96 ± 2.1
Harvesting	25.94 ± 1.9

sternal notch (Ant-L) (cm), and angle of the clavicles (Ant-L) (°) ($p<0.05$).

Similarly, there are significant differences between Group 3 (BMI>30) and Group 2 (25 <BMI <30) among nursery-afforestation workers in terms of the horizontal distance from acromion process to plumb line (Sag-L) (cm) and horizontal distance from acromion process to plumb line (Sag-R) (cm) ($p<0.05$).

An analysis of the variance revealed no significant relationship between the working time and the postural parameters of either nursery-afforestation workers or harvesting workers ($p>0.05$).

DISCUSSION

Significant differences ($p<0.05$) were observed between nursery-afforestation workers and harvesting workers in eight postural parameters of the upper extremities, suggesting the existence of an inverse relationship between increased workload and optimal posture. The reason for this difference is that timber harvesting is a harder task in terms of workload than nursery-afforestation, and this increase in workload results in degeneration of the bones and muscles and an impaired posture due to the associated pain. Frequent and repetitive activities in the job and awkward postures are shown as major contributors of musculoskeletal problems in most of the occupational health studies (Ulu et al. 2009; Trask et al. 2010; Lin 2012; Saha et al. 2015).

Gangopadhyay et al. (2010) found that core-making workers were affected by musculoskeletal disorders like pain at low back (100%), hand (40%), shoulder (30%), wrist (20%) and neck (20%). It has been also found that there is a significant ($p<0.05$) correlation between discomfort level and risk level of the individual working postures of the workers. It was concluded from the study that health of the core-making workers was highly affected by different awkward postures and that they suffer from posture-related musculoskeletal disorders primarily affecting the low back region. Similarly, Hagen et al. (1998) signified that musculoskeletal disorders could generally be attributed to physical factors that are specific to the work being done. The forestry profession has been physiologically defined as a heavy duty profession, and although there has been an increase of machinery usage in the sector substantially over the last 20 years, it is reported the machinery operators are subject to continuous exposure to vibration and the frequent use of their hand, arm, head, neck and shoulder muscles.

May et al. (2012) found that harvesting with the traditional short-handle rake is likely to be associated with increased frequency of pain in general, and mid-low back pain, in particular. Hanklang et al. (2014), on the findings of musculoskeletal disorders among Thai women in construction-related work revealed that 57.7 percent of workers reported musculoskeletal disorder symptoms with low back and shoulders as the most common body parts affected (46.0%). Multiple logistic regression analysis indicated 2 variables that are significantly associated with musculoskeletal disorders: prolonged working hours (adjusted odds ratio = 7.63; 95% confidence interval = 2.06-28.31) and awkward posture (adjusted odds ratio = 43.79; 95% confidence interval = 17.09-112.20). The high prevalence of musculoskeletal disorders among women rebar workers suggests that an appropriate ergonomic workstation design and ergonomic training for women rebar workers are necessary.

Färkkilä et al. (1998) specified attribute numbness, muscle weakness and arm pains to injuries of the peripheral nervous system, reporting intense symptoms in workers who are exposed to high levels of vibration. Of these symptoms, numbness was the most striking and very common in forestry workers in Finland. This is attributable to the activity of the central nervous system, which is due to prolonged exposure to vibration of the arms and hands. Symptoms can also include headache, dizziness, weakness and tremors, while electromyographic findings suggest that other disorders of the central nervous systems are also common in workers who are exposed to vibration. Harvesting workers carry out numerous activities, such as clear cutting, pollarding, unbarking, logging, gravity skidding and timber harvesting using a skyline cable yarding system. These activities are likely to cause postural degeneration due to excessive loading on the muscles and joints in machinery operators.

Gamperiene and Stigum (1999) reported that, sixty-one percent of spinning factory workers suffered from leg pains, fifty-five percent from arm and neck pains, twenty-eight percent from back pain and twenty-five percent suffered from musculoskeletal problems every day. A link has been found between working in a stretched position and certain complaints of the shoulder and upper extremities, but musculoskeletal problems are quite common among people working in different sectors of production. Pains occurring in certain parts of the body may lead to postural impairment, and indicates the presence of a strong relationship between pain and body composition (Guimond and Massrieh 2012).

The findings, related to the positioning of the head, among harvesting workers indicate significant deviations to the right, left and anterior when compared to nursery-afforestation workers and optimal values ($p<0.05$). Previous literature studies suggest that the body position while working is influential on the extremities, and this effect may also cause an interaction between the limbs. For instance, a study conducted of 198 factory workers in Denmark found a positive relationship between prolonged forward bending of the trunk by more than 30 degrees and back pain (Villumsen et al. 2014), while another study found a positive correlation between the angle of the trunk and the neck position and neck pain in workers (Nejati et al. 2014). Likewise, abnormal head positions were associated with the pain levels of people with non-traumatic neck pain (Silva et al. 2009). In the present study, the high value anthropometric measurements recorded among harvesting workers lead to postural impairment due to the application of stresses on the bones, joints and muscles and which also confirm the findings of Nejati et al. (2014), Villumsen et al. (2014) and Silva et al. (2009).

The significant differences observed in the middle of the acromion processes to the plumb line (Ant-L) (cm) and middle of the acromion processes to the plumb line (Ant-R) (cm), according to BMI values in nursery-afforestation workers, are considered to be associated with the repetitive body movement of bending down and straightening up. The position of the body during work can lead to pain, and therefore to impaired body posture (Yamamoto et al. 2004).

Gallagher et al. (2001), found that the applied stresses to the lumbar area was twenty-five percent higher for construction and mining workers, who need to kneel while working. The significant differences observed in the middle of the acromion processes to the plumb line (Ant-L) (cm) and middle of the acromion processes to the plumb line (Ant-R) (cm) measurements are seen as an indication of postural impairment, being a reflection of the stresses applied to the lumbar area, such that an increased BMI causes an increase in lumbar lordosis and sacral curvature (Tüzün et al. 1999). Furthermore, the intensity of activities involving kneeling and straightening up in nursery-afforestation workers in the present study are thought to contribute to impairment in these parameters.

Yakut and Algun (1986) reported that stresses applied to the lumbar area were higher while squatting, and that intra-abdominal pressure must be stable during squatting while holding one’s breath. They suggested that the anterior movement of the lumbar vertebrae while squatting reduces the lever arm of intra-abdominal pressure, and the discordance between the type of motion and respiration (expiration while squatting and inspiration while straightening up) might cause significant problems that may not necessarily be noticed at the time of movement, but at some time in the future. They reported that excessive loading during such activities would cause micro traumas, injury to ligaments, and as a result, irritation of the lumbar nerve roots and muscular spasm, leading finally to irreversible degenerative changes in the lumbar discs. The findings of the present study suggest that physical activities, involving bending down and straightening up, are important factors in postural impairment in nursery-afforestation workers.

CONCLUSION

Forestry activities, known as heavy labor, can lead to intense deformation in the upper extremities through negative effects on anthropometric parameters and the development of an abnormal posture through the application of intense stresses on the muscles and other tissues with increasing workload. This effect was found to be more remarkable for harvesting workers than in nursery-afforestation workers.

The high prevalence of musculoskeletal disorders and awkward postures among harvesting workers suggests that an appropriate ergonomic workstation design and ergonomic training for harvesting workers is necessary.

In addition, it is required that ergonomic principles are applied at the workplace and working equipment conditions are understood step-by-step, especially made suitable for illness of muscle-skeletal system and the problem is solved.

Proper physical therapy programs should be conceptualized to help the workers with muscle-skeletal pain return to their normal physical activities, improve their quality of life, as well as reduce the absence from work.

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