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A Study on Determining the Physical Workload of the Forest Harvesting and Nursery-Afforestation Workers

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ABSTRACT This study examines the physical workload, isometric strength and body composition values of workers working in the forestry industry. Researches in 10 different test areas in total were carried out, including 31 workers of forest harvesting and 30 workers of forest nursery-afforestation in The Regional Directorate of Forestry, Artvin (RDF). As the result of the workload measurement conducted on the workers, the physiological workload (%HRR) of harvesting and nursery-afforestation workers was found as 40.9 percent and 32.4 percent on average, respectively. This finding leads to the conclusion that nursing-afforestation workers can be classified as "light-work" workers, whereas harvesting workers must be classified as "medium-weight work" workers. Heartbeat rates for both worker groups during resting (HRrest) were almost identical; however, the heartbeat rates while at work (HRmax) were found to be higher in harvesting workers than in nursing-afforestation workers, which suggests that harvesting workers are more challenged at some periods of their work activity.

INTRODUCTION

Forestry activities form an organization involving various practices which are mostly performed in outdoor working conditions, including hard work (Apud and Valdez 1995; Apud et al. 2014). This organization includes afforestation, maintenance, protection, harvesting/production, construction, tree nursery, and erosion control (Eroglu et al. 2008; Eroglu et al. 2015). When forestry work is evaluated in general, it differs from other fields of operation due to such factors such as the working conditions, and the place and time of the operation (Erdas and Acar 1995; Zhao and Jackson 2014).

As is the case in several fields of operation, it is also required in the forestry operations that there be some harmony between the worker and the job done in order for the human body to work more efficiently. It is necessary that a worker has a proper physical body to show his physiological capacity at work. A worker cannot expect to reach the highest performance in his work unless the features of his physical body are able to meet the workload he is exposed to. The relationship between the human body at work and the job being done is of great importance.

Physiological workload is a parameter which shows the pressure a worker is exposed to at work is based on his heart rate during his work activities. Heart rate is related to oxygen consumption and can be used to determine the physical workload under certain conditions.

The devices used to measure the heartbeat values consist of the analogue components needed to record the electrocardiography signals and contain different digital components to record the number of heartbeats. Thanks to this method, the load intensity the worker is exposed to during his activities at work can be calculated through formulas (Vitalis 1987; Kirk and Sulmann 2001; Shemwetta et al. 2002; Samsuddin et al. 2015). The physiological workloads of the workers are affected by such physical attributes such as body composition, body mass index (BMI) and strength (Diament et al. 1968; Wortman et al. 2015). The body composition is generally made up of a proportional collection of fat, bones, muscle cells, other organic substances and ex-

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tracellular fluids (Going et al. 1995: Bangsbo et al. 2015). Today the most valid measurement is the body mass index (BMI). The BMI is calculated by dividing the body weight (kg) by the square of the height (m). The ideal weight for a person can be determined by calculating his/her BMI (Sonmez 2003). Another factor associated with physical structure which affects the performance of a person is the concept of "strength". Strength is the ability of the muscles to contract against any resistance they meet or to endure against it for a given period. As another definition, strength is described as the ability to apply a force with short-term maximal efforts and to repeat the submaximal efforts.

In this study, the load intensity at work which the workers, all of whom were male and in charge of harvesting and nursery-afforestation, were exposed to as well as their body compositions and some of their isometric strengths were determined.

MATERIAL AND METHODS

Study Area

Within the scope of this research, studies were conducted in 10 places in total, all of which were located within the boundaries of the RDF (Regional Directorate of Forestry), Artvin (Fig. 1).

Studies were performed at one location in the Ardanuc Forest Nursery, the Seyitler Nursery, Acisu, Natangev, Erenler and Sitimsara, respectively and at 2 location in Varlik and Bogaboynu, respectively (Table 1). The study was conducted on 61 forestry workers, all of whom were males aged between 18 and 61. Of these workers, 31 of them were employed in the harvesting area, while 30 were employed in the nursery-afforestation.

The workers in charge of the areas where harvesting was done performed such tasks such as tree-cutting, branch-collecting, peeling, log-

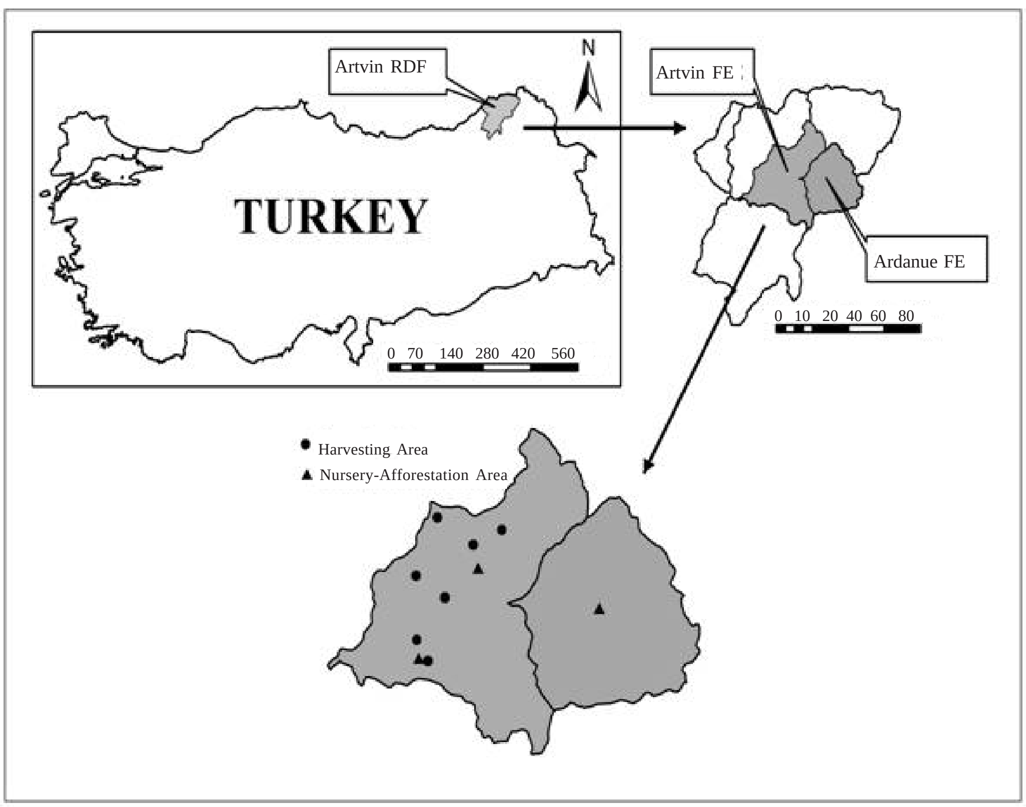

Fig.1. The location of the study points

Table 1: Information about study locations

Study location	*Work*	*Number of workers*	*Division No.*	*Aspect*	*Elevation (m)*	*Slope (%)*	*Tree type*
Acisu	Harvesting	5	30	NE	1100	80	Spruce
Natangev		8	114	SE	1600	50	Spruce
Varlik		2	137	SE	1900	70	Spruce
Erenler (1)		3	150	SE	1900	70	Spruce, Abies
Erenler (2)		3	3	SE	1900	70	Spruce
Sitimsara		7	241	S	1800	60	Spruce
Bogaboynu (1)		3	72	NE	1950	70	Scotch pine
	Total	31					
Bogaboynu (2)	Nursery-Afforestation	8	71	S	1900	70	
Seyitler nursery		7		S	536	1-2	
Ardanuc nursery		15		W	760	1-2	
	Total	30					

ging, cabling to the nearest roadside and wood extraction with cabled overhead lines. The workers in charge of the nursery-afforestation, on the other hand, performed activities such as preparing seedbeds, filling tubes and placing them in harvesting parcels, disinfecting them from pests, shelling, harvesting, sapling-packaging, and sowing. The afforestation workers performed their tasks as part of afforestation activities connected to slope stabilization.

Determining the Strength Values

A back and knee dynamometer was used for measuring the maximal strength of the workers. When knee strength was being measured, the workers were made to place their feet on the dynamometer scaffold with their knees in a bent position and to keep their arms stretched, their back upright, and their chests slightly bent forward. When measuring back strength, the workers were made to sit on the dynamometer scaffold and to keep their legs straight and their back slightly bent, so that they were prevented from moving their legs. The workers were then asked to pull the dynamometer chain with the help of a handle using their maximum strength. These measurements were repeated twice on the workers, and the highest values were taken into consideration.

Determining Body Compositions

The skinfold thickness method was used for measuring body composition. A Holtain-brand skinfold caliper was used for measuring the skin fold thickness. Measurements related to determining the body composition were made in 7 areas, namely the abdominal area, the thigh, the biceps, the triceps, the suprailiac and subscapular areas, and the calf (Zorba and Ziyagil 1995).

The measurements were repeated three times, and their average was recorded in "mm". Later on, the formulas 1, 2, 3 and 4 were used for determining the body fat ratios of the forest workers (Jackson and Pullock 1978; Siri 1956).

$$DB = 1.112 - 0.00043499(\Sigma 7SKF) + 0.00000055(\Sigma 7SKF)^2 - 0.0002826\,(age) \quad (1)$$

$$Fat\ (\%) = [(4.95/dB) - 4.50] \times 100 \quad (2)$$

$$FM = \frac{BM \times Fat\%}{100} \quad (3)$$

$$NFM = BM - FM \quad (4)$$

dB, Body density

SKF, Biceps, Triceps, Subscapular and Suprailiac areas, the Abdominal area, the thigh, Calf skin thickness in "mm" .

Fat (%), Body fat percentage
FM (kg), Body Fat mass
BM (kg), Body mass
NFM(kg), Non-fat mass

Determining the Physiological Workload

The GPSport system was used in order to measure the physiological workloads of the workers in the forest. Afterwards, the GPSport system data were recorded throughout the study, and the obtained data were transferred to the computer environment with the help of Team AMS R1 2011 software. Formula 5 was used to determine the physiological workload (Smith et al. 1985; Trites et al. 1993; Apud and Valdes 1995; Kirk and Parker 1996; Sullman and Byers 2000; Kirk and Sullman 2001; Astrand et al. 2003).

Formula 6 below was used for the purpose of determining half of the heartbeat reserves of the workers (Lammert 1972). The heart rates of the workers at rest and their heart rates during working hours were obtained using Formula 7 (Diament et al. 1968).

$$\%HRR = \times 100 \qquad (5)$$

$$50\%\ I = + \frac{HR_{max} - HR_{rest}}{2} \qquad (6)$$

$$Ratio = \frac{HR_{work}}{HR_{rest}} \qquad (7)$$

%HRR, The number of physical workload

HR_{work} (beat/min), The number of heartbeats during working hours

HR_{rest} (beat/min), The number of heartbeats during resting

HR_{max} (beat/min), The number of maximal heartbeat (= 220 – age)

50% Level, Half of the heartbeat reserves

RESULTS AND DISCUSSION

The values obtained from the measurements performed on the harvesting and sapling-afforestation workers in the study are given in Tables 2 and 3.

As can be seen in Tables 2 and 3, the average ages of the harvesting and nursery-afforestation workers were 43.1 and 44.9, respectively. Their average body weights were determined to be 79.2 kg and 80.4 kg, respectively, whereas their average height was found to be 1.70 m. in both groups. The average body mass index values of the harvesting and nursery-afforestation workers were found to be 26.6 kg/m^2 and 27.1 kg/m^2, respectively. From these results, it is seen that both groups of workers were in the "obese" class. A detailed examination shows that 43 percent of the harvesting workers fall into the "normal" class, whereas 57 percent were in the "obese" class, and that 33 percent of the nursery-afforestation workers were in the "normal" class, while 67 percent were in the "obese" class. In this classification, the criteria used for the BMI were as follows: 20=slim, 20-25=normal, 25-30=obese (Kirk and Sullman 2001: Ramesh 2015).

While the difference between the harvesting workers and the nursery afforestation workers was more prominent due to the fact that the workload of the harvesting workers was far more challenging during the working hours, the fact that the values were proximate to each other may result from the differences in nutritional means.

Similar to the obtained valuess, the studies conducted showed that in chainsaw operators the BMI value was found to be 25.1 kg/m^2 (obese) (Caliskan and Caglar, 2010), whereas this value in overhead line workers was 24.9 kg/m^2 (normal) (Kirk and Sullman 2001) in forest workers 22.6 kg/m^2 (normal) (Dube et al. 2015) and 24.4 kg/m^2 (normal) in the loader tractor drivers (Melemez and Tunay 2010).

Whereas the body density values in both groups of workers were almost identical, it was determined to be 1.059 in the harvesting workers and 1.055 in the nursery-afforestation workers. The body fat percentage of the harvesting workers was 16.77 percent, whereas it was measured as 19.10 percent in the nursery-afforestation workers.

On considering the body fat percentage values and average ages (43.1 in the harvesting workers and 44.9 in the nursery-afforestation workers) of the harvesting and nursery-afforestation workers by using Table 4, the workers are seen to be in the "medium" group (Robers and Roberts 1997: Arora et al. 2015).

$$\frac{(HR_{work} - HR_{rest})}{HR_{maks} - HR_{rest}} \quad HR_{rest}$$

Table 4: Classification of body compositions according to body fat percentages

Group-age	*20-29*	*30-39*	*40-49*	*50-59*	*60≤*
Perfect	<11	≤12	≤13	≤14	≤15
Good	11-13	12-14	14-16	15-17	16-18
Medium	14-20	15-21	17-23	18-24	19-25
Overweight	21-23	22-24	24-26	25-27	26-28
Fat	23<	24<	26<	27<	28<

A detailed look at the body compositions of the workers reveals that 30 percent of the harvesting workers were "perfect", while 3 percent of them were "good", 57 percent were "medium" and 10 percent were "overweight"; and that no "obese" worker was found in this group of workers. On the other hand, it was determined that 24 percent of nursery-afforestation workers were "perfect", 20 percent were "good", and again 20 percent of them were in the "medium" class, while 6 percent were "overweight", and 30 percent were "obese". From these values, it follows that the majority of the nursery-afforestation workers fall into the class of the "obese" class; however, when the general averages are examined, both groups of workers seem to fall into the "medium" class. There is no way of directly measuring the body composition of a living person (Swenor et al. 2015).

Table 2: Parameters of the harvesting workers

Number	Age (years)	Body Weight (kg)	Height (m)	BMI (kg/m²)	dB	Fat %	Fat Mass (kg)	Non-Fat Mass (kg)	KS (kg)	BS (kg)	HR_{rest} (beats/ min)	HR_{max} (beats/ min)	HR_{work} (beats/ min)	% HRR	Ratio	50% I	HR_{work} /50% I
1	19	65	1.77	20.7	1.09	5.7	3.7	61.3	110	75	60	163	132	51.1	2.2	130.5	1.01
2	20	85	1.76	27.4	1.04	22.0	18.7	66.3	70	75	71	174	124	43.4	1.75	132.0	0.94
3	24	71	1.71	24.3	1.08	7.2	5.1	65.9	90	70	59	123	93	24.8	1.58	127.5	0.73
4	26	75	1.80	23.1	1.08	7.2	5.4	69.6	125	115	70	153	116	37.1	1.66	132.0	0.88
5	27	100	1.70	34.6	1.06	18.5	18.5	81.5	140	115	71	174	124	43.4	1.75	132.0	0.94
6	30	63	1.77	20.1	1.05	20.4	12.8	50.2	74	82	60	117	91	27.0	1.52	117.5	0.77
7	33	72	1.75	23.5	1.07	11.1	8.0	64.0	45	35	60	146	102	33.1	1.7	123.5	0.83
8	36	83	1.85	24.3	1.06	17.8	14.8	68.2	45	35	60	139	93	26.6	1.55	122.0	0.76
9	38	84	1.65	30.9	1.04	23.7	19.9	64.1	30	30	60	135	105	36.9	1.75	121.0	0.87
10	39	65	1.69	22.8	1.06	18.0	11.7	53.3	30	40	59	148	128	56.6	2.17	120.0	1.07
11	40	76	1.68	26.9	1.06	18.6	14.1	61.9	85	80	59	141	110	42.1	1.86	119.5	0.92
12	40	84	1.73	28.1	1.04	24.2	20.3	63.7	105	80	60	148	124	53.3	2.07	120.0	1.03
13	43	87	1.78	27.5	1.05	20.4	17.7	69.3	110	80	60	145	111	43.6	1.85	118.5	0.94
14	43	70	1.72	23.7	1.07	12.0	8.4	61.6	80	40	62	167	118	48.7	1.9	119.5	0.99
15	45	65	1.65	23.9	1.05	20.4	13.2	51.8	30	25	60	134	95	30.4	1.58	117.5	0.81
16	45	83	1.74	27.4	1.07	14.4	11.9	71.1	130	115	60	117	91	27.0	1.52	117.5	0.77
17	46	82	1.73	27.4	1.07	12.7	10.4	71.6	160	140	60	141	100	35.1	1.67	117.0	0.85
18	46	68	1.71	23.3	1.06	17.8	12.1	55.9	82	50	60	91	80	17.5	1.33	117.0	0.68
19	46	94	1.72	31.8	1.04	25.2	23.7	70.3	65	60	61	166	131	61.9	2.15	117.5	1.11
20	47	97	1.67	34.8	1.05	14.4	13.9	83.1	30	50	60	140	108	44.0	1.8	114.5	0.94
21	50	83	1.74	27.4	1.06	17.2	14.3	68.7	160	120	62	147	115	49.1	1.85	116.0	0.99
22	51	95	1.72	32.1	1.04	25.0	23.8	71.2	110	125	60	140	108	44.0	1.8	114.5	0.94
23	51	67	1.66	24.3	1.05	20.9	14.0	53.0	50	55	60	138	103	39.4	1.72	114.5	0.90
24	51	95	1.67	34.1	1.06	18.6	17.6	77.4	110	95	60	132	117	52.3	1.95	114.5	1.02
25	54	70	1.65	25.7	1.05	20.7	14.5	55.5	75	30	56	141	120	58.2	2.14	111.0	1.08
26	56	92	1.79	28.7	1.06	17.8	16.4	75.6	65	70	60	161	100	38.5	1.67	112.0	0.89
27	56	87	1.86	25.1	1.07	12.5	10.9	76.1	120	110	60	165	105	43.3	1.75	112.0	0.94
28	57	90	1.77	28.7	1.06	17.9	16.1	73.9	100	90	59	147	107	46.2	1.81	111.0	0.96
29	58	77	1.73	25.7	1.05	20.6	15.8	61.2	35	30	60	142	117	55.9	1.95	111.0	1.05
30	59	65	1.68	23.0	1.08	9.5	6.2	58.8	70	40	70	125	100	33.0	1.43	115.5	0.87
31	61	65	1.70	22.5	1.08	7.6	4.9	60.1	35	30	60	120	85	25.3	1.00	109.5	0.55
Avarage	43.1	79.2	1.73	26.6	1.059	16.77	13.51	65.69	82.7	70.6	61.3	143	108	40.9	1.76	118.7	0.90
Min	19	63	1.65	20.1	1.04	5.7	3.7	59.3	30	25	56	91	80	17.5	1.00	109.5	0.55
Max	61	100	1.86	34.8	1.09	25.2	23.8	76.2	160	140	71	174	132	61.9	2.20	132.0	1.11

BMI= Body Mass Index, dB=Body Density, Fat%= Body Fat Percentage, KS= Knee Strength, BS= Back Strength, HR_{rest}(beats/min)= Heartbeat during resting, HR_{max} (beats/min)= Maximum heartbeat, HR_{work}= Heartbeat during working,
%HRR= Physiological workload; Ratio = The ratio of heartbeat during working to heartbeat during resting; 50%I = Heartbeat half-reserve; HR_w /%50I = Ratio of heartbeat during working to heartbeat half-reserve

Table 3: Parameters of the nursery-afforestation workers

Number	Age (years)	Body Weight (kg)	Height (m)	BMI (kg/m²)	dB	Fat %	Fat Mass (kg)	Non-Fat Mass (kg)	KS (kg)	BS (kg)	HR_{rest} (beats/min)	HR_{max} (beats/min)	HR_{work} (beats/min)	% HRR	Ratio	50% I	HR_{work} /50% I
1	18	63	1.73	21.1	1.08	7.0	4.4	58.6	90	80	60	169	116	39.4	1.93	131	0.89
2	21	80	1.70	27.7	1.07	14.2	11.3	68.7	130	85	68	188	127	45.0	1.87	134	0.95
3	21	75	1.80	23.1	1.07	11.3	8.5	66.5	70	90	70	125	100	23.3	1.43	135	0.74
4	29	65	1.60	25.4	1.07	12.0	7.8	57.2	75	70	65	122	87	21.8	1.50	125	0.70
5	29	115	1.90	31.9	1.06	17.7	20.4	94.6	170	165	60	183	118	44.3	1.97	126	0.94
6	31	70	1.67	25.1	1.07	14.1	9.9	60.1	65	60	68	141	118	45.0	1.97	125	0.95
7	42	60	1.74	19.8	1.08	6.3	3.8	56.2	20	25	64	93	82	18.6	1.37	119	0.69
8	43	80	1.72	27.0	1.05	19.3	15.5	64.5	60	60	60	118	74	17.6	1.42	115	0.65
9	45	97	1.77	31.0	1.04	25.8	25.1	71.9	100	80	67	127	100	39.2	1.66	111	0.90
10	45	82	1.73	27.4	1.05	20.4	16.7	65.3	55	45	64	99	70	11.8	1.25	116	0.61
11	45	85	1.73	28.4	1.07	13.8	11.7	73.3	95	115	69	130	97	32.2	1.62	118	0.83
12	46	90	1.65	33.1	1.04	28.2	25.4	64.6	40	30	60	127	100	39.2	1.66	111	0.90
13	48	58	1.63	21.8	1.08	8.0	4.6	53.4	60	35	66	112	80	17.9	1.33	116	0.69
14	48	82	1.74	27.1	1.05	20.6	16.9	65.1	50	40	60	128	97	33.0	1.62	116	0.84
15	48	70	1.69	24.5	1.06	15.6	10.9	59.1	75	75	68	116	97	33.0	1.62	116	0.84
16	49	72	1.67	25.8	1.04	24.9	17.9	54.1	35	35	60	112	87	24.3	1.45	116	0.75
17	49	60	1.60	23.4	1.07	14.0	8.4	51.6	60	80	67	120	89	26.1	1.48	116	0.77
18	50	90	1.66	32.7	1.04	26.3	23.6	66.4	85	90	60	127	100	39.2	1.66	111	0.90
19	51	95	1.75	31.0	1.03	29.6	28.1	66.9	55	65	65	136	96	33.0	1.60	115	0.84
20	52	83	1.66	30.1	1.04	27.0	22.4	60.6	35	30	60	132	107	43.5	1.78	114	0.94
21	52	95	1.77	30.3	1.03	29.2	27.7	67.3	35	40	60	152	106	42.6	1.77	114	0.93
22	54	70	1.76	22.6	1.07	11.5	8.0	62.0	30	25	60	99	72	12.1	1.22	113	0.64
23	55	78	1.73	26.1	1.04	26.3	20.5	57.5	55	60	60	113	80	19.0	1.33	113	0.71
24	55	105	1.79	32.8	1.04	24.7	25.9	79.1	80	65	65	97	81	20.8	1.37	112	0.72
25	55	65	1.75	21.2	1.05	19.4	12.6	52.4	40	35	61	128	101	39.0	1.68	113	0.90
26	56	60	1.59	23.7	1.07	14.1	8.4	51.6	50	40	67	119	93	31.7	1.55	112	0.83
27	58	108	1.75	35.3	1.03	32.1	34.7	73.3	60	50	64	127	100	39.2	1.66	111	0.90
28	59	80	1.74	26.4	1.05	21.1	16.9	63.1	80	70	65	129	102	41.0	1.67	111	0.92
29	59	100	1.73	33.4	1.03	28.9	28.9	71.1	85	75	70	125	105	47.2	1.91	108	0.97
30	34	78	1.78	24.6	1.08	9.7	7.6	70.4	160	130	67	160	127	53.2	2.12	123	1.03
Avarage	44.9	80.4	1.72	27.1	1.055	19.10	16.15	64.25	70	64.8	64	129	97	32.4	1.62	117.2	0.83
Min	18	58	1.59	19.8	1.03	6.3	3.8	54.2	20	25.0	60	93	70	11.8	1.22	108	0.61
Max	59	115	1.9	35.3	1.08	32.1	34.7	80.3	170	165	70	188	127	53.2	2.12	135	1.03

BMI= Body Mass Index, dB=Body Density, Fat%= Body Fat Percentage, KS= Knee Strength, BS= Back Strength, HR_{rest}(beats/min)= Heartbeat during resting, HR_{max} (beats/min)= Maximum heartbeat, HR_{work}= Heartbeat during working,
%HRR= Physiological workload; Ratio = The ratio of heartbeat during working to heartbeat during resting; 50%I = Heartbeat half-reserve; HR_w /%50I = Ratio of heartbeat during working to heartbeat half-reserve

However, this value can be determined through a number of calculations. In this paper, starting from the body fat percentages of the forestry workers, the fat-mass and non-fat mass values were obtained. It is important to estimate the fat mass value, since this value represents the energy reserve of the body; on the other hand, the non-fat mass value is an important indicator of the muscle and skeleton structure of the body, and for this reason it is related to the body's state of fitness (Apud and Valdes 1995; Schoenfeld et al. 2015).

While the body weight average of the harvesting workers was 79.2 kg, this value in the nursery-afforestation workers was 80.4 kg. As a result of the calculations made, the fat-mass ratios of the harvesting and nursery-afforestation workers were calculated as 13.51 kg and 16.15 kg, respectively. The non-fat mass values in the harvesting and nursery-afforestation workers were determined to be 65.69 kg and 64.25 kg, respectively. From these results, it can be concluded that the nursery-afforestation workers are heavier than the harvesting workers. The average fat-mass of the nursery-afforestation workers is higher than that of the harvesting workers; however, there is no significant difference in terms of their non-fat mass. In other words, it can be said that the energy reserves of the nursery-afforestation workers are at higher levels, whereas the muscular and skeletal development of the harvesting workers is in better condition. In a study conducted in Chile, the average weight value of forestry workers was calculated as 63.4 kg, while their body fat-mass was 16.8 kg and their non-fat mass was 52.7 kg (Apud and Valdes 1995). In the other study conducted in Turkey, the average weigth values of forestry workers were determined as 73.1 kg (Enez et al. 2014).

From the obtained values, it follows that 20 percent of the weight values of the nursery-afforestation workers were made up of fat masses, whereas this ratio for the harvesting workers was 16 percent. This ratio in the forestry workers in Chile, on the other hand, was found to be 26 percent, which shows that the energy reserves of the forestry workers in Chile are higher than those of the forestry workers in this study (Apud and Valdes 1995). On the other hand, on considering their non-fat masses, 76 percent of the weight values of the nursery-afforestation workers in this study were calculated as non-fat mass, whereas this ratio was 79 percent in the harvesting workers. This ratio in the forestry workers in Chile, however, was calculated to be 83 percent (Apud and Valdes 1995). Both of the values are seen to be lower in comparison to those of the Chilean forestry workers. The reason for such an outcome may be considered to be the fact that the Chilean forestry workers are better trained in terms of nutritional means.

The knee strength values of the harvesting and nursery-afforestation workers were found to be 82.8 kg and 70 kg, respectively. The back strength values of the harvesting and nursery-afforestation workers were determined to be 70.5 kg and 64.8 kg, respectively. As will be understood, the measured values in the harvesting workers proved to be higher, which can be evaluated as an indicator of the fact that the harvesting workers have a greater endurance for such conditions. If we considering the forestry tasks to be the same as the exercises that athletes do, it is normal that the harvesting workers become more resilient towards these tasks as they are challenged more due to the activities they perform.

Apart from the forestry sector, in some studies aiming at finding out the isometric strength values, the knee strength value of mountaineers was found to be 88.4 kg (Ozkan and Sarol 2008), whereas in another study, the back strength values of soccer players, basketball and volleyball players were determined to be 70.08 kg, 65 kg and 62.36 kg, respectively (Aydos et al. 2004). It follows from these values that forestry workers and the individuals taking part in certain sports have very similar strength values to each other.

Some heartbeat values were used in determining the workload level of the workers. These values are Physiological Workload (Vitalis 1987; Minard 1971; Saha 1978; Singh 2015), the ratio of the heartbeat value during working hours to the heartbeat ratio during resting (Diament et al. 1968; Fordham et al. 1978; Goldsmith et al. 1978: Böhm et al. 2015) and the 50 percent level (Lammert 1972) values. In addition, starting from the average heartbeat value during working hours, the intensity value of the work was identified (Grandjean 1980).

When the physiological workloads were compared, it was determined that the physiological workload (%HRR) values of the harvesting workers were 40.9 percent on average, while the physiological workload (%HRR) values of the nursery-afforestation workers were 32.4 percent on average (Fig. 2).

Table 5 shows what class the work performed according to heartbeat measurements and physiological workload level (Vitalis 1987; Kirk and Sullman 2001; Shemwetta et al. 2002; Grandjean 1980; Parker et al. 1999) is in. From this point, considering the workload levels of the harvesting workers during working hours, it follows that while 33 percent of the workers fall into the "light" work group and 67 percent into the "medium" work group, they are generally considered within the "medium" work group; and while 51percent of them fall into the "light" work group and 49 percent into the "medium" work group, they are generally considered to be within the "light" work group.

Table 5: Workload levels

Work level (beats/min	*Heartbeat (beats/min)*	*Physiological workload (%)*	*Energy consumption (Kcal/min)*
Light	70-90	0-36	<0.5
Medium	90-110	36-78	2.5-5.0
Heavy	110-130	78-114	5.0-7.5
Very heavy	130-150	114-150	7.5-10.0
Extremely heavy	150-170	>150	>10.0

As the result of the measurements performed during the chainsaw and branch pruning studies carried out in New Zealand, the physiological workload values of the workers were determined to have varied between 30 percent and 37 percent (Parker et al. 1999). It was also determined that this value had varied between 31percent and 60percent during chainsaw cutting, logging and ground-skidding activities (Kirk and Parker 1996). Kirk and Sullman (2001) found the physiological workload of the workers to be 36.4 percent while working on the forest skyline. In another study conducted in New Zealand, Kirk and Parker (1996) determined that the physiological workload of those in charge of the pruning was 29 percent. As the result of the measurements performed during forestry harvesting practices in Tanzania, the physiological workload value was found to be 49 percent (Abeli and Malisa 1994) whereas Shemwetta et al. (2002) found this value to be 67 percent in forestry harvesting activities.

On the other hand, in another study conducted in Turkey, it was found that the physiological workload of forestry workers using chainsaws at work was 44.79 percent (Caliskan and Caglar 2010). However, in another study performed by Melemez et al. in Turkey (2011), it was determined that the physiological workload value of the

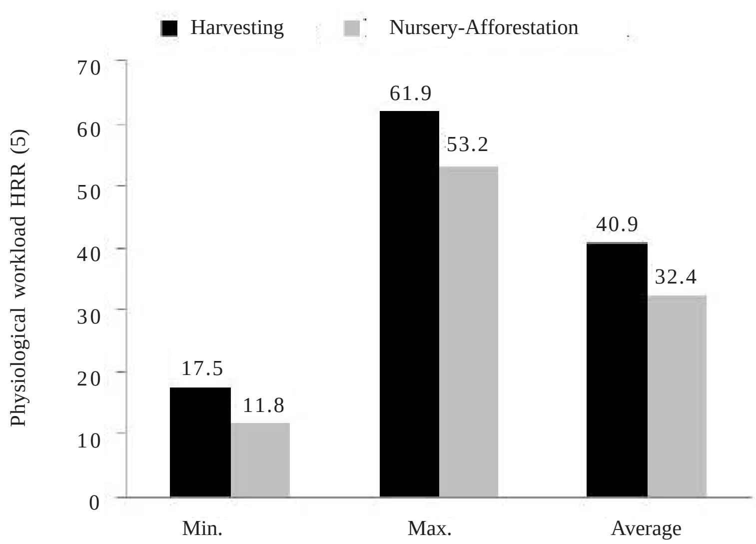

Fig. 2. Physiological workload of the harvesting and nursery-afforestation workers (% HRR)

chainsaw workers was 36.59 percent. In this study, this value was determined to be 20.17 percent for the tractor workers. Separately, Melemez and Tunay (2010), in the study they conducted, found that the workers using loading machines had a physiological workload value of 49 percent. It was seen through these conducted studies that the physiological workload value was affected by the type of work and the challenges experienced by the workers during their activities. Likewise, due to the same kind of reasons within the scope of this study, it is likely that the physiological workload value of the harvesting workers proved to be higher than the physiological workload of the nursery-afforestation workers, considering the degree of hardship they are faced with.

The heart rates at the time of resting (HR_{rest}) were assessed as 61.2 beats/min in the harvesting workers and 60 beats/min in the nursery-afforestation workers on average, while the maximum heart rates during working hours (HR_{max}) were 142.5 beats/min in the harvesting workers and 128.4 beats/min in the nursery-afforestation workers. The average heart rates during working hours (HR_{work}) were 108.1 beats/min in the harvesting workers and 96.9 beats/min in the nursery-afforestation workers on average (Fig. 3).

Within the scope of the study, the heartbeat values of the workers during resting were found to be between 60 and 80 beats/min, which were accepted as normal values (Sonmez 2003). These values suggest that the HR_{rest} values of both the harvesting and nursery-afforestation workers were within normal limits. The fact that the HR_{rest} values of the harvesting workers proved to be lower than those of the nursery-afforestation workers can be said to be due to the fact that the harvesting workers are accustomed to performing heavier tasks. In a study conducted in New Zealand, it was found that the HR_{rest} value of forestry workers was 79 beats/min (Kirk and Parker 1996). However, in a study conducted in Turkey on forestry workers using chainsaws, it was found that the HR_{rest} values of the workers was 70.5 beats/min (Grandjean 1980). In another study conducted in our country, it was determined that the HR_{work} values of chainsaw operators was 72.7 beats/min (Melemez et al. 2011). The heartbeat values of forestry workers in Tanzania and Australia during their resting hours was found to be 68 beats/min (Abeli and Malisa 1994).

The HR_{max} value was found to be 165 beats/min for forestry workers in Tanzania (Abeli and Malisa 1994). Another study conducted in Italy suggests that the HR_{max} value for skidding activities performed with a tractor proved to be 127 beats/min (Cristofolini et al. 1990). Another study conducted on young swimmers determined this value to be 186 beats/min. In this study, the low level of HR_{max} values in forestry workers can be attributed to their high average age (43.1 in the harvesting workers and 44.9 in the nursing-afforestation workers).

Taking these values into account, it is seen that both jobs can be classified as "medium-weight work". The reason for which the HR_{work} values of the harvesting workers were higher compared to the nursing-afforestation workers was that the workload level of the harvesting workers during activity was higher, which can be said to cause an increase in the heart rate (Fig. 3).

Heartbeat is a reliable tool for displaying the physiological workload (Roja 2005). In a study conducted in Tanzania, the heart rate of workers while doing manual loading was found to be 178 beats/min. In the same study, this value during logging activities was determined to be 133 beats/min (Shemwetta et al. 2002).

A study conducted in Turkey suggests that the heart rate of chainsaw workers during working hours was found to be 122.8 beats/min (Caliskan and Caglar 2010). In another study conducted in Turkey, it was found that the heart rate in tractor operators was 94 beats/min, while in chainsaw workers it was 108 beats/min (Melemez et al. 2011). In New Zealand in 1996, Kirk and Parker found that the average heart rate of pruning workers was 112 beats/min. The heart rate during cutting-down and peeling activities proved to be 112 and 120 beats/min, respectively (Abeli and Melisa 1994). In New Zealand, the heart rate of overhead line workers during working hours was determined to be 106 beats/min (Kirk and Sullman 2001). In a study conducted in Chile, however, it was determined that the average heart rate of afforestation workers was 106 beats/min. The same study showed that the heartbeat rate during pruning was 120.9 beats/min (Apud and Valdes 1995).

When these studies are analyzed, it can once again be seen that the heart rates and the degree of the strength needed for the work to be done were directly proportionate. One cannot ignore the possibility that environmental conditions can have an effect on the heart rate during working

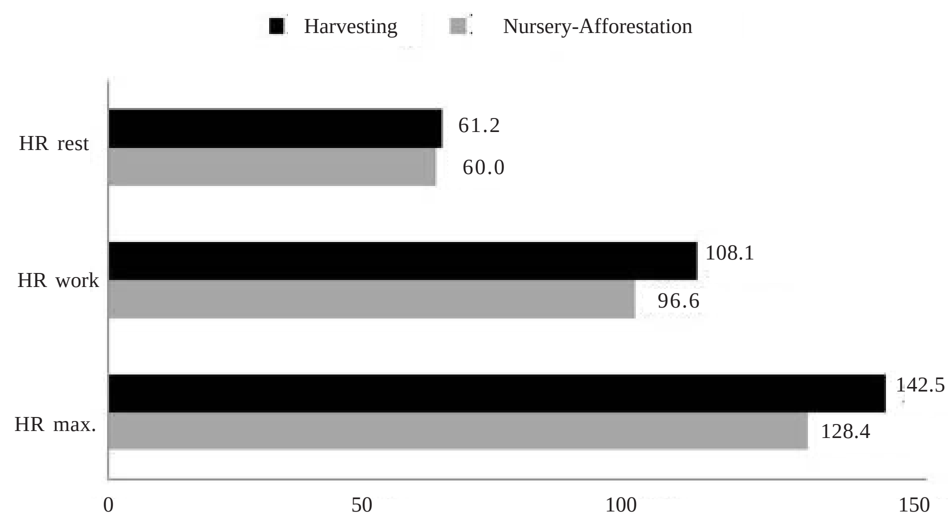

Fig.3. Maximum (HR_{max}) and average (HR_{rest}) heart rate values of the harvesting and nursery-afforestaton workers during resting

hours. It is true that with the an increase in temperature and humidity, the body's system will be more challenged, and the heart rates of the workers will therefore also increase. Moreover, the tools used for work can also be considered as an important factor in terms of the change in the average heart rate.

The ratio of the heart rates of workers at work to the ratio of the heart rates during resting was determined to be 1.75 in the harvesting workers and 1.61 in the nursing-afforestation workers on average, respectively (Fig. 4). This value was found to be 1.45 in the pruning workers (Kirk and Parker 1996). A study conducted in Turkey

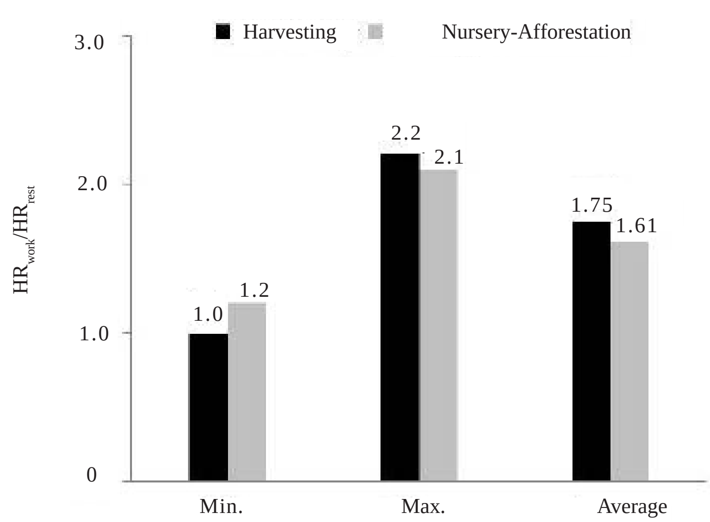

Fig. 4. Ratio of heart rates of the harvesting and nursing-afforestation workers to heartbeat rates durng resting (HR_{work}/HR_{rest})

found the HRwork/HRrest value in chainsaw workers to be 1.74 (Caliskan and Caglar 2010). In addition, Goldsmith et al. (1978) found this value to be 1.45 in car body workers. However, another study showed this value to be 1.37 in steel workers (Vitalis 1987).

The heartbeat half-reserve values of the workers was found to be 115.4 in the harvesting workers and 116.9 in the nursery-afforestation workers on average (Fig. 5).

Considering the HR_{work}/50% I value, the last of the physiological parameters showing the ratio of the heart rate during working hours to the heartbeat half-reserve rate, it was seen that this value was 0.9 in the harvesting workers and 0.8 in the nursing-afforestation workers on average, respectively (Fig. 6).

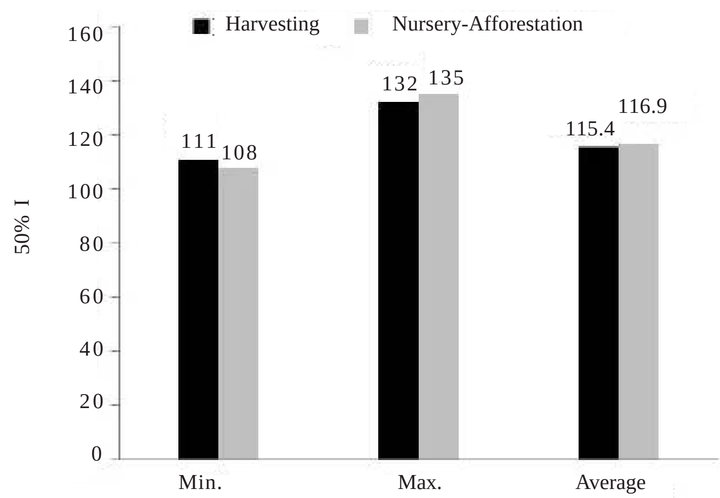

Fig. 5. Half-reserve heart reat values of the harvesting and nursing-afforestation workers (% 50)

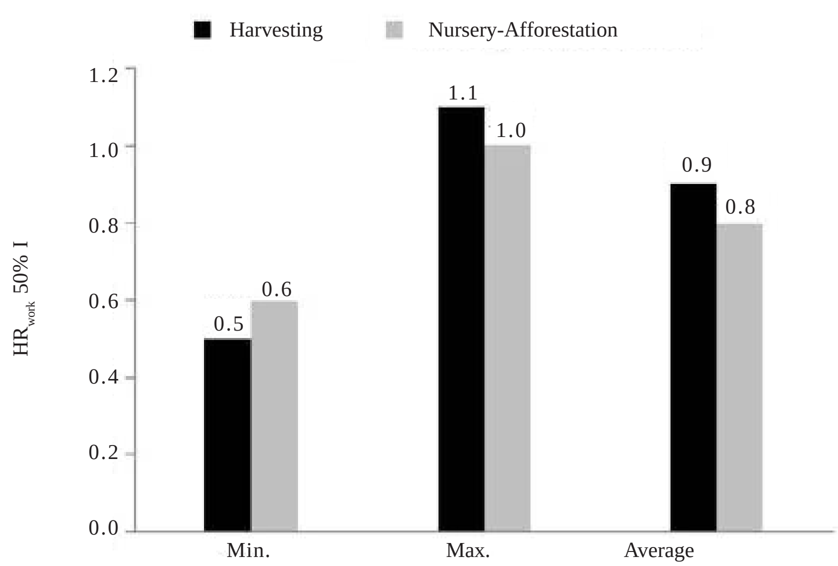

Fig. 6. HR_{work}/50% I values of the harvesting and nursing-afforestation workers

Put forward by Lammert (1972) and used by Vitalis et al. (1987) the HR_{work}/50% I value obtained by dividing the heart rate during working hours (HR_{work}) by the heartbeat half-reserve rate (%50 I) is a simple and effective method in minimizing the workload of the workers. If this value during activity/working hours is "1", then the work is regarded as a "Continuous Heavy Duty" (Lammert 1972). In this paper, this value was found to be 0.90 in the harvesting workers and 0.82 in the nursing-afforestation workers, which, when examined, suggests that the workload level in the groups of workers does not fall into the "Continuous Heavy Duty" class owing to the fact that the value in both of the groups of workers is lower than "1", although these are proximate values. In a study conducted in our country, this value was found to be 0.97 in chainsaw operators (Caliskan and Caglar 2010). In another study conducted in New Zealand, it was found that this value was 0.82 in pruning workers (Kirk and Parker 1996).

CONCLUSION

The resting and working periods of the forestry workers should be periodically controlled during operational activities. In particular, occasional abnormal changes that may occur in the heart rates of workers can have negative impacts on their health status. Considering that their heart rates are affected by factors such as age, weight and height, the workers must be equipped with tools that are most suitable for them so that their workload pressure can be mitigated.

In particular, since the harvesting workers do various jobs with different levels of intensity, and thus it becomes hard for them to concentrate on a single activity, the workload and heartbeat rate values of the workers during the working hours cannot be brought under control. This issue can be improved by means of a decent work plan and a resulting action plan.

As harvesting activities are far more challenging when compared to nursing-afforestation activities, it should be decided as to what jobs the workers should be assigned to by considering their bodily strength and body composition values.

The real performance values (aerobic capacities) to be exhibited by the would-be workers during activity should be determined, and the workers must be selected and employed accordingly.

RECOMMENDATIONS

Abnormal changes of workers heart rates may be can negative effects on the health of workers. Therefore, it should be provided that suitable work for worker's anthropometric and physiological properties. Rest periods and exposure time of forest workers should be regulated according to the theirs workload. Forestry workers should be subjected to health checks periodically. Workers should be fed as balanced and healthy diet taking into account the energy they spend daily.

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