Determination of Physiological Workloads of the Harvesting Workers: A Case Study from Artvin

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Abstract:

In this study, physiological workloads were determined based upon heart beatings values measured for harvesting workers and body composition and isometrical force values of the workers were measured. The study was conducted on 31 harvesting workers who all are males at 7 study areas which belongs to the Artvin Forest Enterprise. In conclusion, Physiological Workloads (%HRR) of the harvesting workers were determined and it was specified that these workers were working in "Medium-level work" according to average heart beating values (HRw) measured during the work. Furthermore, knee strength value of these workers was determined averagely as 82.8 kg, back strength value of these workers was determined averagely as 70.5 kg, and body fat of these people was determined as %16,33. When average age of the workers is taken in consideration, we conclude that body fat percentage values of the workers is within "medium" group, and when Body Mass Index values are taken in consideration we conclude that workers are in the "fat" group.

Keywords: Physiological workloads, Isometric force, Body composition, Harvesting workers, Ergonomics, Artvin.

Introduction:

In order for people to work efficiently in most fields, including forestry, they have to establish harmony between themselves and their work. People have to have sufficient physical power so that the physiological power needed for the relevant work can be displayed. Unless the physical condition is adequate to meet the workload encountered at work, desired performance cannot be obtained.

Physiological workload is a parameter which shows the pressure that the worker encounters during working based on the heartbeat frequency during working (Vitalis 1987). Heartbeat frequency is related to oxygen consumption and can be used for determination of physical workload. The devices used for determining heartbeat frequency values consist of analogue components needed for recording electrocardiographic signals and can host different digital components in order to record heartbeat rates. With this system, the strength of the load that a person is exposed to can be calculated through formulas (Kirk and Sulmann 2001).

Such parameters as body composition, body mass index (BMI) and force can be mentioned among the physical features of workers. Body composition consists of the coming together at certain rates of fats, bones, muscle cells, other organic materials and non-cell liquids. Gender, muscles, physical activities, diseases and dietary habits can be listed among the most important factors that affect body composition which is closely related to the life of people. As regards body composition measurement techniques, basic point of departure is finding the body density and estimating and calculating body fat percentage based on that value.

We need energy in order to be able to perform the variety of activities in our daily lives. The need for energy must be calculated according to the body weight, height, age, gender and physical activities. Some formulas have been developed to measure fat ratio using weight and height measures. The most widely used measure today is body mass index (BMI), which is calculated by dividing body weight (kg) with the square of height (m). By calculating BMI, the ideal weight of a person can be estimated (Sönmez 2003).

Another factor which affects performance related to physical structure is “strength”. According to Hollmann, strength is the ability of muscles to contract against any force or to endure when met with resistance (Sevim 1997). In another definition, it is termed as the ability to apply force in short-term maximal efforts and repeat sub-maximal efforts (Plisk 2003).

Within the scope of this paper, the purpose is to determine the leg and back strength values (isometric strength) of forest workers working at production activities, all of whom are males, and body composition values; another purpose is to measure the strength of workload that they are exposed to during working.

Material and Method: Within the scope of this study, measurements were made in 7 sections all of which are located within Artvin Forestry Directorate. Physical workloads, isometric strength values and body compositions of 31 production workers, all of whom are males and between the ages of 19 and 61, were identified. The measures were recorded on the sketch form which was previously prepared.

In the areas where production activities are performed, workers conduct such activities as tree-cutting, branch-taking, paring, segmenting, skidding with cabling to the closest roadside and wood extraction with cable overhead lines.

Back and leg dynamometer were used for measuring strength. Measurements were repeated twice on workers and the highest values obtained were taken into consideration. In body composition measurements, skinfold thickness method was employed. Skinfold thickness was determined by using Holtain brand skinfold caliper and measurements were made at abdominal thigh, biceps, triceps, sprailiac, suskapula, and calf areas of the workers (Zorba and Ziyagil 1995). Measurements were made three times and average values were recorded in “mm” kind. Later, the following formulas (formulas 1, 2, 3 and 4) were used for measuring body fat rates of the forest workers (Jackson and Pullock 1978).

dB = $1.112 - 0.00043499\left(\sum 7SKF\right) + 0.00000055\left(\sum 7SKF\right)^2 - 0.0002826\left(yaş\right)$ (1)

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

Fat mas in body (FMB)= $\frac{B.C \times \%Fat}{100}$ (3)

Non-Fat mass (NFM)= $B.C - FMB$ (4)

dB, Body density
SKF, Skin thickness of biceps, triceps, sprailiac, suskapula, abdominal, calf, upper leg in “mm” kind
Fat (%), The Fat percentage in the body
FMB (kg), Fat mass in body
B.C (kg), Body composition
NFM (kg), Non-Fat mass

GPSport method was employed in order to determine the workload of the workers. The device connects to the satellite; therefore, before performing measurement in related areas, connection was ensured between the device and satellite in open field. In the meantime workers were rested for 10 minutes. Afterwards the workers were asked to take off their clothes on the upper part of their body and the device was installed onto their back through a back-apparatus. Then a chest-tape was located onto the chest of the workers right onto their heart and their heartbeat values during working were recorded. The data generated by GPSport system during working was recorded and the obtained data were transferred into computer environment via Team AMS R1 2011 software.

Formula 5 was used in order to determine physiological workload with the obtained data, which is widely used in the literature (Kirk and Sullman 2001; Sullman and Byers 2000; Kirk and Parker 1996; Apud and Valdes 1995; Trites et al. 1993; Astrand et al. 2003).

$$\text{Physical workload (HRR\%)} = \frac{(HR_w - HR_r)}{HR_{\max} - HR_r} \times 100 \quad (5)$$

Formula 6 was used in order to determine the half of the heartbeat reserves of the workers (Lammert, 1972).

$$\text{50\% level} = HR_r + \frac{HR_{\max} - HR_r}{2} \quad (6)$$

The heartbeat of the worker during resting and working were obtained through formula 7 (Diament et al., 1968).

$$\text{Ratio} = \frac{HR_w}{HR_r} \quad (7)$$

HRw (beat/min), the number of heartbeats during work
HRr (beat/min), the number of heartbeats during resting
HRmax (beat/min), the maximum number of heartbeats (=220 – age)
50% level, half of the heartbeat reserves.

Results and Discussion:

The data obtained from measurements made within the scope of this study on 31 production workers are provided in Table 1. As can be seen from this table, average age of the production workers is 43,1, average body weight is 79,2 kg and average height is 1,70 meters.

Table 1. Parameters measured for production workers

Parameters	Minimum	Maximum	Average
Working period (min)	100	135	122
Age	19	61	43,1
Body weight (kg)	63	100	79,2
Height (m)	1,65	1,86	1,70
BMI (kg/m2)	20,1	34,8	26,6
dB	1,04	1,09	1,1
Fat %	5,7	25,2	16,8
Fat mass (kg)	3,7	23,8	13,5
Non-fat mass (kg)	42,6	82,6	62,4
LS (kg)	30	160	82,8
BS (kg)	25	140	70,5
KAist (beat/min)	56	71	61,3
KAmax(beat/min)	91	174	142,6
KAiş (beat/min)	80	132	108,2
HRR%	17,5	61,9	40,9
Ratio	1	2,2	1,8
50%Se	109,5	132	118,6
KAiş/50%Se	0,55	1,11	0,9

BMI(kg/m2) = body mass index; dB =body density; % body fat percentage; LS(kg) leg strength; BS(kg) =back strength; HRr (beat/min)= heartbeat during resting; HRmax (beat/min)= Maximum heartbeat; HRw (beat/min)= average heartbeat during working; %HRR= physiological workload; Ratio = the ratio of average heartbeat during working to heartbeat during resting; 50%Le = heartbeat half-reserve; HRw /%50Se = ratio of heartbeat during working to heartbeat half-reserve

The average body mass index rate was found as 26,6 kg/m2. From the obtained findings, it has been determined that the workers are under the “fat” category. This classification used the following BMI measurements: 20=thin, 20-25=normal, 25-30=fat (Kirk and Sullman 2001). Another study conducted in our country BMI value of chainsaw operators was measured as 25,1 kg/m2 and the workers were classified as “fat” (Çalışkan and Çağlar 2010). In another study the same value for workers of overhead lines was found as 24,9 kg/m2 (Kirk and Sullman 2001). According to this classification, these workers display lower BMI values and can be included in the “normal” category.

Body density value was measured as 1,06 and average body fat percentage was measure das 16,3 percent. When Table 2 is examined, production workers are classified under "medium" group based on their body fat percentage values and average age values (Robergs and Robert 1997).

Table 2. Comparison of body compositions according to body fat percentage

Classification-age	20-29	30-39	40-49	50-59	60≤
Excellent	<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<

Body weight average value for the workers was found as 79,6 kg. As a result of relevant calculations, fat mass value was estimated as 13,5 kg for these workers, whereas non-fat mass value is 61,2 kg. In the literature of forestry, this kind of studies are rare; however, a study conducted in Chile found average weight value of the forest workers as 63,4 kg, body fat mass as 16,8 kg, and non-fat mass as 52,7 kg (Apud and Valdes 1995).

Some studies related to calculating isometric force values except forestry industry, the leg strength of mountaineers was found as 88,4 kg (Özkan and Sarol 2008); in another study, the back strength of soccer players, basketball players and volleyball players was found as 70,08 kg, 65 kg and 62,36 kg, respectively (Aydos et al. 2004).

As oxygen exit cannot be recorded, energy consumption during working could not be calculated. Therefore some heartbeat values have been obtained in order to measure the workloads of production workers. By this means, it was possible to measure the strength of several works comparatively. These indicators are physiological workload (Minard et al. 1971; Saha 1978; Vitalis et al. 1994); the ratio of heartbeat values during working to heartbeat values during resting (Fordham et al. 1978; Goldsmith et al. 1978) and 50% level values (Lammert 1972). In addition the strength of the conducted work can be determined based on average heartbeat value during working (Rodahl 1989; Grandjean 1980).

The physiological workload (HRR%) values of production workers was determined as 40,9% on average (Figure 1).

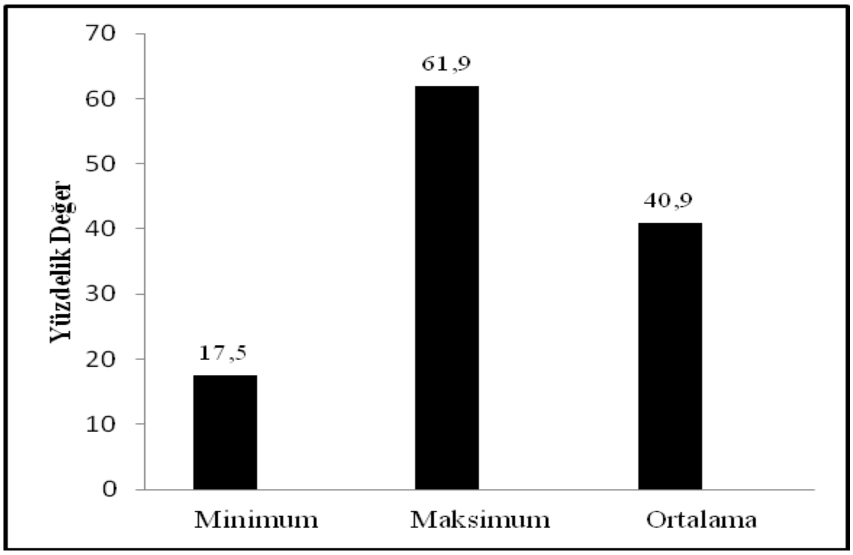

Figure 1. Physiological workload (%HRR) value of harvesting workers

Table 3 shows the classification of works depending on the heartbeat measurements and physiological workload levels (Grandjean 1980; Vitalis 1987; Parker 1999; Kirk and Sulmann 2001; Shemwetta et al. 2002). When the workload levels of production workers during work is examined, 33% is grouped under "light work" category whereas 67% was grouped under "medium-level work" category, meaning in a general sense they are classified as "medium-level work".

Table 3. Workload levels

Work level	Heartbeat (beat/min)	Physiological workload (%)
Light	70-90	0-36
Medium	90-110	36-78
Heavy	110-130	78-114
Very Heavy	130-150	114-150
Extremely heavy	150-170	>150

Another study conducted in Turkey found the physiological workload value of forest workers who use chainsaw as 44,79% (Çalışkan and Çağlar 2010). Another study conducted in Turkey (Melemez et al. 2011) found the physiological workload values of chainsaw workers as 36,59%. This value was found as 20,17% in tractor workers. As a result of the measurements made during tree trimming with chainsaw in New Zealand, the physiological workload values of workers was found between 30% and 37% (Parker et al. 1999). Measurements mad during forestry production activities in Tanzania, physiological workload was found as 49 percent (Abeli and Malisa 1994). Shemwetta and others found this value for forestry production activities in 2002 as 67 percent. These studies showed that physiological workload value is affected by the type of work and straining of workers during working.

Average heartbeat rate of the workers during working is 108,1 beat/min. In 1995, Kirk and Parker found the average heartbeat value of forest tree-trimming workers as 112 beat/min. Other authors determined that average pulsation during tipping and paring activities was 112 and 120 beat/min, respectively (Abeli and Melisa 1994). Another study conducted in Turkey found the heartbeat rates of chainsaw workers during working as 112,8 beat/min (Çalışkan and Çağlar 2010). Another study conducted in our country found the average heartbeat rate of tractor operators as 94 beat/min and of chainsaw workers as 108 beat/min (Melemez et al. 2011).

Average heartbeat rates of production workers during resting is 61,2 beat/min. This study found that the heartbeat rates of workers during resting were in the 60-80 beat/min interval which is accepted as the normal value (Sönmez, 2003). These figures show that HRr values of workers are within normal boundaries. A study conducted in New Zealand found the HRr values of workers as 79 beat/min (Kirk and Parker 1995). A study conducted on chainsaw workers in Turkey found their HRr value as 70,5 beat/min (Çalışkan and Çağlar 2010).

When the maximum heartbeat rates of workers during working are examined, it is determined that the average value is 142,5 beat/min. This value was found as 165 beat/min for forest workers in Tanzania (Abeli and Malisa 1994). Another study conducted in Italy found the HRmax value in tractor-assisted skidding activities as 127 beat/min (Cristofolini et al. 1990).

The ratio of heartbeat rates of workers during working to the same rate during resting is 1,75 on average this value is found as 1,45 for tree-trimming workers (Kirk and Parker 1995). One study conducted in Turkey found the HRw/HRr rate for chainsaw workers as 1,74 (Çalışkan and Çağlar 2010).

Average Heart-beat half reserve rate of workers is 115,4. When HRw/50%Le value, which is the last physiological parameter showing the rate of heartbeat rate during working to heartbeat half-reserve, is examined, it can be seen that this value varies between

0,5 and 1,1 for workers and that the average value is 0,9.

The value of HRw/50%Le value, which is suggested by Lammert (1972) and used by Vitalis et al. (1994), is obtained by dividing the heartbeat value during working (HRw) by heartbeat half-reserve (50%Le). It is a simple and effective method for measuring the workload of an active worker. If this value is equal to "1" during the study, it is accepted as "continuous heavy work" (Lammert 1972). In this study, this value was found as 0,82 for plantation workers. When these values are examined, it can be said that this value is lower than 1 for both groups of workers, therefore it cannot be classified as "continuous heavy work". However they are close values. A study conducted in our study found this value for chainsaw workers as 0,97 (Çalışkan and Çağlar 2010). Another study conducted in New Zealand identified this value for tree-trimming workers as 0,82 (Kirk and Parker 1996).

Conclusions: This paper concludes that, according to the BMI values, production workers can be included in the "fat" category, and that they have "medium" level of fat according to body fat percentages.

According to the workload measurement conducted on workers, physiological workload value of production workers (HRR%) was detected as 40,9 percent, which means that production workers perform a job which is categorised as "medium-heavy work".

Average heartbeat values during working (HRw) were found as 108,1 beat/min. heartbeat values during resting (HRr) were found as 61,2 beat/min on average and maximum heartbeat rates during working were determined as 142,5 beat/min for workers.

Average ratio of heartbeat values of workers during working to the heartbeat values during resting (HRw / HRr) was found as 1,75; heartbeat half-reserve values (50%Le) was found as 115,4 on average; and the ratio of heartbeat values during working to heartbeat half-reserve values (HRw /50%Le) was determined as 0,9 on average for workers. According to these values, it has been concluded that the production workers do not perform a job which is classified as "continuous heavy work".

Some recommendations can be made based on these conclusions:

The calories consumed by workers during working should be determined and thus they must be urged to take a healthy and balanced diet; their body composition values should be kept under control.

Attention must be paid to ensure that workers who will be employed in production are more experienced and husky. In other words, the workers should be employed in jobs which are appropriate for their anthropometric and physiological structure.

In terms of our country, the researches conducted on workers employed in the field of forestry are not sufficient. In this context the issue must be handled with an integral and ongoing approach and studies on workers must be proliferated.

Negative impacts can be witnessed on the health of forest workers due to abnormal changes in values which can take place in the heartbeat values of workers from time to time. Considering that heartbeat values are affected by such factors as age, height and weight, it must be ensured that workers use tools and machines which are suitable for themselves; thus, possible workload pressure on workers can be prevented.

As works with a variety of weight are conducted in production activities and as the worker does not focus on a single activity, the workload and heartbeat values of workers during working cannot be kept under control. This problem can be cured with a decent work plan and by extension a good action plan.

The real performance values that the workers can display during working (their aerobic capacities) should be determined and workers should be selected and employed accordingly.

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