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Production rate and work strain on workers in cutting of pines in Tanzania

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SELOSTE: TYÖN TUOTTAVUUS JA TYÖNTEKIJÄN KUORMITTUMINEN MÄNNYN HAKKUUSSA TANSANIASSA

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A team of 2 experienced workers was timestudied and their heart rate recorded under 4 days in clearcutting of a highly selfpruned *Pinus patula* plantation. Task work and bonus payment systems were compared, but there was no difference in production rate, only the workplace time was extended from 2.3 h/d in task work to 3.9 h/d in bonus payment. The heart rate was 115–116 P/min in felling, 105–109 P/min in debranching and 109–114 P/min in bucking. The average heart rate in timber cutting was 108–109 P/min. Work load index was 34–37 %, and the workers did not show any symptoms of accumulated stress. The production rate was 3.2 m^3/h, (WPT, crew), which correponds average piecework rate, the comparable walking speed being about 6.0 km/h. There are possibilities to increase the daily task by ergonomic grounds.

Tutkimuksessa seurattiin kokenutta 2 miehen työryhmää 4 päivää mittaamalla heidän tuotostaan aikatutkimuksin ja rekisteröimällä syketaajuus. Työvälineinä oli justeeri ja 2 kirvestä. Normi- ja bonuspalkkaa kokeiltaessa todettiin, että työtahti pysyi samana kumpaakin maksuperustetta käytettäessä, mutta työmaa-aika kasvoi 2,3 tunnista 3,9 tuntiin päivässä kun siirryttiin normipalkasta bonuspalkkaan. Syketaajuus kaadon aikana oli 115–116 P/min, karsinnassa 105–109 ja 109–114 katkonnassa. Kuormittuneisuusaste oli 34–37 %, eikä ylikuormittuneisuuden oireita ollut havaittavissa. Tuotos oli 3,2 m^3 työryhmän työmaatuntia kohti, mikä vastaa urakkatyötahtia ja kuormittavuudeltaan 6,0 km/h kävelynopeutta. Ergonomisin perustein päivänormia voidaan nostaa.

Keywords: payment system, production rate, rating
ODC 35+307+304+305+(678)

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1. Introduction

There are already several studies in Tanzania on production rate and time consumption in timber cutting operation, based on time studies (Nangawe 1976, Dallu 1977, Abeli 1978, Kimaryo 1979, Migunga 1982, Ole-Meiludie 1984). However, few studies have been carried out on the relationship between work load and working capacity of Tanzanian forest workers (Abeli and Ndossi 1984, Saarilahti and Abeli 1985). The objective of this study was to assess production rate and work load in cutting of a mature pine plantation.

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2. Materials and methods

21. Data collection

Data were collected in November 1984 at Sao Hill Forest Project, situated in Mufindi district of Iringa region in the Southern highlands of Tanzania. The altitude varies between 1 800 m and 2 000 m; temperature fluctuates between an average monthly maximum of 23 °C and an average minimum of 10 °C. No heat stress is thus evident.

For this study a 26-year-old *Pinus patula* compartment was clearfelled. The compartment had previously been thinned (row thinning) at 50 percent removal intensity. The terrain was moderately flat and even.

Data on cutting operation was collected from detailed time study using continuous timing, timing both workers of a team simultaneously. The following independent variables, expected to influence the production rate and work load, were measured and recorded:

- Stump diameter, cm
- Diameter at breast height, cm
- Total tree height, m
- Height to the first living branch, m
- Volume, m^3 (o.b) by measuring individual log diameters at butt, mid and top, and length.

Table 1. Characteristics of the studied crew.
Taulukko 1. Tekomiesten henkilötiedot.

Characteristic – *Ominaisuus*	Member A	Member K
Age – *Ikä*, a	30	33
Weight – *Paino*, kg	69	62
Height – *Pituus*, m	1.73	1.74
Working experience – *Työkokemus*, a	8	8
VO_2 -max., L/min	3.1	2.7

Work load was estimated by measuring the subject's heart rate using a SPORT TESTER (Saarilahti and Abeli 1985), a small portable heart rate registration unit storing into its memory the average heart rate over 5 seconds every 30 s. The storage capacity of the memory is 64 min, but during the study the readings were taken after every tree. This reading was an extra element, "reading time", under which the workers took a small rest.

The study objects were two experienced permanent workers of Sao Hill Sawmill Ltd. A two-man crew was picked up from the foreman's subjective class "Average workers". The crew's data is presented in Table 1.

Table 2. Summary statistics of tree variables.
Taulukko 2. Puustoa kuvaavat muuttujat.

Variable *Muuttuja*	Mean *Keskiarvo*	Minimum *Pienin arvo*	Maximum *Suurin arvo*
DBH, $D_{1.3}$, cm	26	15	44
Volume – *Tilavuus*, m^3	0.632	0.056	1.849
Merchantable length – *Tukkiosan pituus*, m	14.2	3.2	24.9
Total tree height – *Puun pituus*, m	24	17	29
Crown ratio* *Latvussuhde*	0.38	0.17	0.63

*) Crown ratio = 1 – (height to the first living branch/tree height)

22. The amount of data

The study covered 5 days: one tree was cut and the walk test was carried out during the first day. Four days were used for the main study. The total workplace time was 759 min (12 h 39 min). A total of 71 trees were cut: 65 were of merchantable size, containing at least one minimum sawlog (minimum 14 cm top diameter), 6 were non-merchantable. The trees had good stem form with small tapering. The average tree volume was 0.633 m^3, see Table 2.

23. Work organization

The scheduled working day was from 07:30 to 15:30, with a 0.5 h lunch break. The workers were transported to and from the worksite, the travelling time averaging about 1 hour one way. The workers were provided with a meal; usually none of the workers returned to the workplace after the lunch having completed their task of 12 trees per team in good time before the lunch break.

The cutting tools per team consisted of one two man crosscut saw and 2 axes. No wedges were used. The saw was well maintained, but the axes were not in good condition.

Two different payment systems were used during the study:

- task work, 12 trees per crewday (present situation)
- bonus work, the daily pay being 30 sh + a bonus of 2.50 sh per man per tree. In this case arrangement was made to bring the workers to the worksite earlier than normal.

24. Data analysis

The data on cutting time and heart rate was analysed by allocating the heart rate reading to different work elements by tree, and the average heart rate per tree was used as a independent (or dependent) variable in regression analysis. Average heart rate by elements were computed, however, by summing up all the readings, thus being time weighted averages.

3. Results and discussion

31. Production rates in timber cutting

Production rates in the different payment systems were compared. It was found out that there was no difference in production rates between the two payment systems, see Table 3. The higher daily production in bonus system was obtained by lengthening the workplace time from 2.3 h to 3.9 h. Variation of production rate in the different work elements were as follows: (The hour stands for crewhour, equal to two menhours)

Felling

Production rate in felling based on stump basal area, varied from 1.0 to 3.50 m^2/h, the average being 2.06 m^2/h. The felling cutting rate was not correlated with any independent

Table 3. Average production rate in timber cutting.
Taulukko 3. Keskimääräinen tuotos hakkuussa.

Time concept – *Aika*	Task work *Normipalkka*	Bonus work *Bonuspalkka*
m^3/day* – *m^3/päivä**	7.32	12.71
m^3/scheduled hour – *m^3/työvuorotunti*	0.92	1.59
m^3/effective hour – *m^3/tehollinen tunti*	4.09	4.00
m^3/workplace hour – *m^3/työmaatunti*	3.18	3.29

* Day refers to crew day (equal to two mandays) Hour refers to crew hour
* *Päivä käsittää 2 miestyöpäivää. Tunti käsittää 2 miestyötuntia*

variable tested, so neither tree size nor heart rate explained variations in felling production rate.

Bucking

Bucking production rate varied from 0.45 to 2.58 m^2/h, the average being 1.77 m^2/h. The production rate was significantly correlated with tree characteristics and heart rate.

$$RBU = 1.97+0.012 \cdot DBH+0.020 \cdot HR_a+0.012 \cdot HR_k \quad R^2 = 28.9\,\% \quad N = 65 \qquad (1)$$

where

RBU is production rate in bucking, m^2/h (crew)
DBH diameter at breast height, cm
HR_a heart rate of subject A in bucking
HR_k heart rate of subject K in bucking

Debranching

Production rate in debranching was rather constant, 16.0 m^3/h.

Total timber cutting

The production rate in total timber cutting varied from 0.96 to 6.94 m^3/h, the average production being 3.5 m^3/h. The best models explaining the total timber cutting production rate were as follows:

$$RTT = -19.03-0.624 \cdot DBH+7.73 \cdot \sqrt{DBH} \quad R^2 = 60.3\,\% \quad N = 65 \qquad (2)$$

$$RTT = 1.61+4.72 \cdot V-1.8 \cdot V^2 \quad R^2 = 61.1\,\% \quad N = 65 \qquad (3)$$

where

RTT is production rate in timber cutting per total timber cutting time, m^3/h (crew).
V tree volume, m^3
DBH diameter at breast height, cm

Equations 2 and 3 suggest that the production rate was strongly influenced by tree size; the production rate increases as a function of tree size, the function being degressive in form. Heart rate did not enter into the model, but the heart rate was correlated with production rate.

32. Heart rate

The average heart rate by work elements is presented in Table 4. The heart rates of the two workers were intercorrelated in total timber cutting ($r = 0.333^{**}$). Higher correlations were found in "compulsory" team work, such as in felling sawing ($r = 0.435^{***}$) and bucking ($r = 0.336^{**}$), the highest correlation being in maximum pulse ($r = 0.436^{***}$). When comparing the heart rate trends of the two workers it was found to be parallel (increasing or decreasing simultaneously) in 51 cases (84 %) and opposite in 10 cases (16 %), but the level changed irregularly. The work influences on the heart rate, but there is a remarkable personal factor too.

Investigation on the factors affecting heart rate for both workers indicated that the heart

Table 4. Heart rate, P/min, by work elements.
Taulukko 4. Syketaajuus, P/min, työvaiheittain.

Subject *Tekomies*	Felling *Kaato*	Debranching *Karsinta*	Bucking *Katkonta*	Total timber cutting *Puutavaran teko*
	Heart rate – *Syketaajuus*, P/min			
A	114	105	112	108
K	114	108	107	106

Work element – *Työvaihe* (spanning Felling, Debranching, Bucking, Total timber cutting)

rate was correlated with tree size, DBH, as follows:

$$HRTT_a = 98.0+0.390 \cdot DBH \quad R^2=27.5\,\% \quad N=65 \qquad (4)$$

$$HRTT_k = 96.0+0.405 \cdot DBH \quad R^2=19.8\,\% \quad N=65 \qquad (5)$$

where

$HRTT_a$ is heart rate of subject A in total timber cutting, P/min
$HRTT_k$ heart rate of subject K in total timber cutting, P/min
DBH diameter at breast height, cm

The heart rate of subject A seemed to decrease towards the end of the day; the residuals of equation (4) were correlated ($r = 0.363^{**}$) with the ordinary number of tree cut during the day. Subject K's heart rate seemed to vary irregularly within the day. The production rate was also significantly correlated with heart rate ($r_a = 0.352^{**}$, $r_k = 0.361^{**}$),though only 10 % of the total variation was explained by increase in production rate. This could be explained by saw pinching, or bad work posture in some cases, when the production rate decreases but the heart rate increases.

33. Recovery of the workers

Reading time was the time needed to remove the recording unit from the neck of the workers, to record the readings and to put the unit back. Because of the automatic running display the reading time mainly depended on the number of stored values, thus of the total timber cutting time or tree size, see Table 5. The average reading time was 14 % of work-

Table 5. Average reading time, first pulse of the following tree and maximum pulse for diameter classes.
Taulukko 5. Syketaajuuden mittausaika, aloituspulssi seuraavalla puulla sekä maksimipulssi eri kokoisilla puilla.

DBH, $D_{1.3}$, cm	15–19	20–24	25–29	30–34	35–39	40–45
First next tree pulse – *Aloituspulssi seuraavalla puulla*, P/min						
Worker A	86	82	85	84	94	95
K	86	86	86	89	94	86
Maximum pulse – *Maksimi syketaajuus*, P/min						
Worker A	119	123	122	134	138	142
K	125	127	135	137	139	139
Reading time – *Syketaajuuden mittausaika*, min						
	1.2	1.4	1.5	2.0	2.4	2.5

place time or 16 % of total timber cutting time. The reading time, during which the workers usually stood immobilized, could be assumed long enough for workers to recover since the first pulse of the next tree was independent of the tree size, see Table 5. The maximum heart rate increases as a function of tree size, but the reading time increases also, allowing an adequate recovery.

34. Work load

The work load index was calculated using two different methods:

Method A: using equation 6 (based on Lange Andersen's et al. 1969 data)

Method B: using equation 7 (from Mälkiä 1974).

$$WLI = -57.1 + 0.762 \cdot HR + 0.00266 \cdot HR \cdot A \quad (6)$$

where
WLI is work load index, %
HR heart rate, P/min.
A age, a

$$WLI = 100 \cdot \frac{HR - HR_r}{HR_m - HR_r} \quad (7)$$

where
WLI is work load index, %
HR heart rate for the work element
HR_m maximum heart rate, P/min
HR_r rest pulse, P/min

The maximum heart rate was a calculated value, 220 -age in years. The measured rest pulse was 63 P/min for the subject A and 62 P/min for the subject K.

The work load indices and assessments after the two methods for the different work elements are presented in Table 6. Both of the workers seem to have equal load, having approximately same working capacity and working pace. Their work load (34–37 %) was within acceptable limits: Bonjer (1977) recommends that allowable energy expenditure for an 8½ h working day to be at maximum one third of the worker's maximum power (WLI = 33 %). The average WLI for the studied subjects is of the same magnitude, but the working day was only 2–3 h. Åstrand (1960) recommends that WLI greater than 50 % should be avoided. Lange Andersen et al. (1969) recommend a lower ratio, 40 %, which in this study was attained momentarily only in the felling operation.

Table 6. Work load indices and assessment for the different work elements.
Taulukko 6. Kuormittuneisuusaste työvaiheittain.

Element *Työvaihe*	Subject A *Tekomies A* Heart rate *Syketaajuus* P/min	Work load index and assessment *Kuormittuneisuusindeksi ja -aste* Method A	Method B	Subject K *Tekomies K* Heart rate *Syketaajuus* P/min	Work load index and assessment *Kuormittuneisuusindeksi ja -aste* Method A	Method B
Felling *Kaato*	116	40-M	42-M	115	40-M	42-M
Debranching *Karsinta*	105	31-M	33-M	107	33-M	36-M
Bucking *Katkonta*	114	38-M	40-M	109	35-M	38-M
Walking *Siirtyminen*	89	17-L	20-L	88	17-L	21-L
Clearing *Raivaus*	105	31-M	33-M	103	30-M	33-M
Breaks *Tauot*	93	21-L	24-L	100	27-L	30-L
Total timber cutting *Puutavaran teko*	109	34-M	36-M	108	34-M	37-M

The work load assessment: *Kuormittuneisuusaste:*
M = Moderate *M = kohtuullinen*
L = low *L = alhainen*

Table 7. Energy expenditure and heart rate for the different work elements.
Taulukko 7. Energian kulutus ja syketaajuus työvaiheittain.

Work element *Työvaihe*	Subject – *Tekomies* A: Energy expenditure *Energian kulutus* kJ/min	A: Heart rate *Syketaajuus* P/min	K: Energy expenditure *Energian kulutus* kJ/min	K: Heart rate *Syketaajuus* P/min
Felling *Kaato*	26.7	116	23.5	115
Debranching *Karsinta*	21.6	105	20.9	107
Bucking *Katkonta*	25.8	114	21.6	109
Timber cutting *Puutavaran teko*	24.9	112	21.9	110
Walking *Siirtyminen*	14.2	89	14.7	88

35. Energy expenditure

The energy expenditure was estimated based on the walk test, using the heart rate/walking speed function (Saarilahti 1986) and the following energy expenditure equation in walking:

$$EE = W \cdot (0.08 + 0.00777 \cdot S^2) \quad (8)$$

were
EE is energy expenditure, kJ/min.
W body weight, kg
S walking speed, km/h

Estimates for the energy expenditure in the different work elements are presented in Table 7. The total energy expenditure for the main times was between 22–25 kJ/min while that for the total timber cutting was somewhat lower (21–24 kJ/min.); this is mainly due to the lower rates in the by-elements. It may also be noted that the energy expenditure of subject K was lower than that of A probably due to the lower body weight and heart rate in most of the work elements.

36. Daily energy expenditure

Table 8 presents the estimated daily energy expenditure at two productivity levels:

- current productivity: 2 m^3/manday in timbercutting and 1 h in agricultural work
- high productivity: 8 m^3/manday in timbercutting and 1 h in agricultural work.

The energy expenditure in timber cutting is based on Table 7. The energy expenditure during the sleep and leisuretime is based on interview and estimates. The daily energy expenditure was about 14 MJ at the current level. It corresponds the energy expenditure of "very active" males, see Table 9. If the workplace time increases from current 79 min (1h 19 min) to 316 min (5h 16 min) the daily energy expenditure will be 16.3–16.9 MJ, corresponding to the class "exceptionally active", but still under the recommended daily maximum (20 MJ/d after Grandjean 1982).

Table 8. Estimated daily energy expenditure at two productivity levels.
Taulukko 8. Arvioitu päivittäinen energian kulutus kahdella tuotostasolla.

Activity	Current production *Nykyinen tuotostaso*					High production *Korkea tuotostaso*				
Toiminta	Subject A			Subject K		Subject A			Subject K	
	min	kJ/min	kJ	kJ/min	kJ	min	kJ/min	kJ	kJ/min	kJ
Sleeping *Nukkuminen*	480	4.6	2208	4.6	2208	480	4.6	2208	4.6	2208
Sedentary work *Kevyt työ*	225	12.5	2812	12.5	2812	168	12.5	2812	12.5	2812
Active work *Aktiivinen työ*	195	14.6	2847	14.6	2847	165	14.6	2146	14.6	2146
Farm work *Peltotyöt*	60	20.0	1200	20.0	1200	60	20.0	1200	20.0	1200
Rest *Lepo*	281	8.5	2389	8.5	2389	149	8.5	1267	8.5	1267
Leisure *Vapaa-aika*	761	12.2	9248	12.2	9248	524	12.8	6713	12.8	9398
Felling *Kaato*	16	26.8	429	23.5	376	64	26.8	1715	23.5	1504
Debranching *Karsinta*	17	21.6	267	20.9	355	68	21.6	1469	20.9	1421
Bucking *Katkonta*	27	25.8	697	21.6	583	108	25.8	2786	21.6	2333
Others *Muut*	19	16.5	264	17.3	277	76	16.5	1254	17.3	1315
Travelling *Työmatka*	120	6.5	780	6.5	780	120	6.5	780	6.5	780
Work *Työ*	199	12.7	2537	11.9	2371	436	18.3	8004	16.9	7353
Total *Yhteensä*	1440	9.7	13993	9.6	13827	1440	11.8	16925	11.3	16274

37. Performance rating

The use of walk test gives a possibility to use the British Performance rating as a reference. However, it should be noted that the calculation method is not a standard method, but an attempt to compare the working pace of the workers to a certain standard. Table 10 gives the Performance Rating Index and the comparable walking speed.

Based on the heart rate of an element the corresponding comparable speed can be calculated and the Performance Rating Index assessed, Table 11. The comparable walking speed was about 6 km/h, and the working pace was close to the normal piecework performance (Table 10). The work pace was lower in debranching than in felling or bucking; this could be due to the fact that the workers had more "hidden" breaks in debranching than in the other elements. These results suggest that the workers have probably adapted a certain working pace which was rather close to the piece work performance; the workers' interest possibly being to fulfil the daily task in the shortest possible "comfortable" time. This observation could be supported by the following facts:

- there was no variation in production rate between the two payment systems, only the work place time changed;
- work load index was between 30–40 %, which is considered as recommended "normal" value.

It is evident that the workers are able to keep this pace for a longer period of time, but the energy (food) intake becomes the limiting factor.

Table 9. Daily energy expenditure, MJ, of a 65 kg man on different activity levels (after FAO 1976).
Taulukko 9. 65 kiloisen miehen päivittäinen energian kulutus, MJ, eri aktiviteettitasoilla. (FAO 1967).

Activity class – *Aktiviteetti*			
Light activity *Vähän aktiivinen*	Moderately active *Kohtuullisen aktiivinen*	Very active *Hyvin aktiivinen*	Exceptionally active *Poikkeuksellisen aktiivinen*
Energy expenditure – *Energian kulutus*, MJ/d			
11.3	12.0	14.6	16.7

Table 10. Performance Rating Index and comparable walking speed (after Scott 1973).
Taulukko 10. Joutuisuuskerroin ja vastaava kävelynopeus Scottin (1973) mukaan.

Performance rating index *Joutuisuuskerroin*	Comparable walking speed *Vastaava kävelynopeus* km/h	Observation *Huom.*
50	3.2	
75	4.8	Time work performance – *Aikatyötahti*
100	6.4	Piecework performance – *Urakkatyövauhti*
125	8.0	
150	9.6	

Table 11. Performance Rating Index and the comparable walking speed for different work elements.
Taulukko 11. Joutuisuuskerroin ja vastaava kävelynopeus työvaiheittain.

Work element *Työvaihe*	Heart rate *Syketaajuus* P/min Subject		Performance Rating Index *Joutuisuuskerroin* Subject		Comparable walking speed *Vastaava kävelynopeus* km/h Subject	
	A	K	A	K	A	K
Felling *Kaato*	116	115	98	98	6.3	6.3
Debranching *Karsinta*	105	107	86	89	5.5	5.7
Bucking *Katkonta*	114	109	97	92	6.2	5.9
Main time *Pääaika*	112	110	94	92	6.0	5.9

4. Conclusions and recommendations

Tfhe working technique and the physical working capacity of the workers were good due to the long experience in logging. The workers could keep piecework performance without any symptoms of fatigue and the resting time about 16 % of the timbercutting time was adequate in avoiding the stress to accumulate.

When compared to the recorded average daily production at Sao Hill Sawmill Ltd (Micski & Stridsberg 1981), it can be seen that the production rate of the crew, m^3/h(WPT) is nearly as high as the daily production of a man, see Figure 1. (The small discrepancy at smaller trees is due to the fact that the recorded production rate for smaller diameters comes from thinnings, where the production rate is lower than in clearcutting). This suggests that the daily task could be increased. The workers are able to achieve their daily task in 2.3 h when working at piecework performance. The rated WPT is 3.1 h, which still is fairly low.

If 6.5 h WPT is considered "fair", the actual daily task should double. As the work load is moderate and the daily energy expenditure under recommended limits, the increase is possible on the ergonomic grounds. Using the time work performance and letting the 6 h 30 min workplace time the following daily production equation can be calculated:

$$DT = -80.0 - 2.62 \cdot DBH + 32.48 \cdot \sqrt{DBH} \qquad (9)$$

where

DT is (maximum) daily task, m^3 for a team of 2 workers

DBH breast height diameter, cm

The daily task for different diameters is calculated in Table 12. If these daily tasks are applied the adequate energy (food) intake should be guaranteed at the same time.

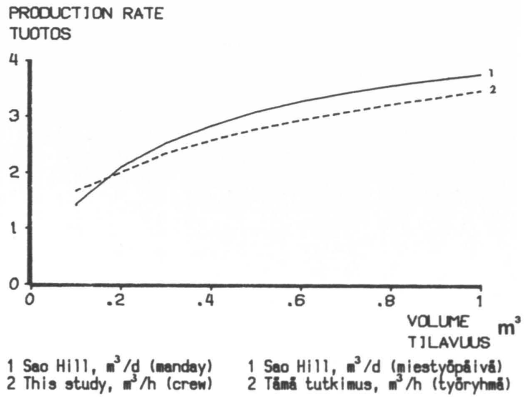

Figure 1. Production rate as a function of tree size
Kuva 1. Hakkuutuotoksen riippuvuus puun tilavuudesta

Table 12. Recommended (maximum) daily task for a team of 2 workers in clearcutting of highly selfpruned (Crown ratio 0.38) *Pinus patula* stand.
Taulukko 12. Suositeltu korkein päivänormi kahden miehen työryhmälle hyvin karsiutuneen (latvussuhde 0,38) Pinus patu*lan avohakkuuseen.*

DBH, $D_{1.3}$ cm	Task *Normi* m^3
20	13.2
25	17.4
30	19.9
35	21.1
40+	21.4

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Seloste

Työn tuottavuus ja työntekijän kuormittuminen männyn hakkuussa Tansaniassa

Tutkimuksessa seurattiin 4 päivän ajan yhtä tansanialaista kahden miehen työryhmää *Pinus patula* männyn hakkuussa. Työvälineinä oli 2 kirvestä ja justeeri. Työmiehet olivat puutavaran tekoon tottuneita, ja heillä oli 8 vuoden työkokemus. Sydämen sykintätaajuus mitattiin Sport Tester-rekisteröintilaitteella, joka tallentaa 5 s keskisyketaajuuden 30 s välein. Syketaajuudet luettiin jokaisen puun jälkeen, josta aiheutui pieni tauko normaaliin työrytmiin. Tutkimuksen aikana miehet työskentelivät 2 päivää normipalkalla (12 puuta/päivä työryhmää kohti, normaali käytäntö) ja 2 päivää bonuspalkalla (päiväpalkka + 1,50 TAS puulta). Työtahti pysyi palkkauksesta riippumatta samana, tuotoksen ollessa 4,0 m^3/h (tehoaika) mutta työmaa-aika kasvoi 2,3 tunnista 3,9 tuntiin. Tuotos oli puun koosta riippuvainen. Myös sydämen sykintätaajuus kohosi puun koon kasvaessa. Keskimääräinen sykintätaajuus oli työvaiheittain seuraavan asetelman mukainen:

	Työntekijä A	Työntekijä K
Kaato	116	115
Karsinta	105	107
Katkonta	114	109
Puutavaran teko	109	108

Kuormittuneisuus arvioitiin sykintätaajuuden perusteella. Keskimääräinen kuormittuneisuusaste puutavaran teossa oli kohtuullinen (WLI 34–37 %), ja kohosi korkeimmillaan 40–42 %:iin kaadon aikana. Sykintätaajuuden perusteella arvioitiin työtä vastaava kävelynopeus, jota voitiin verrata englantilaiseen joutuisuuskertoimeen. Työtahti vastasi n. 6 km/h kävelyn syketaajuutta, ja oli täten lähellä urakkatyötahtia. Työmiesten työtekniikka oli hyvä ja tauot lyhyitä, joten tuntituotos on korkea, 3,2 m^3/h. Alhainen päivätuotos johtuu lyhyestä työmaa-ajasta, 2,3 h/d. Tekomiehet näyttivät täydellisesti palautuvan sinä aikana, mikä tarvittiin Sport Tester-laitteen lukemiseen, n. 16 % puutavaran tekoajasta.

Tekomiesten päivittäinen energian kulutus on n. 14 MJ. Työmaalla tarjotaan yksi lämmin ateria päivässä.

Päivänormia voidaan nostaa huomattavasti ergonomisin perustein.

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