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PHYSICAL WORK PERFORMED BY SURGEONS DURING ORTHOPAEDIC OPERATIONS

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During an operation the surgeon performs physical work to a greater or lesser extent. As far as we know the amount of this work load has not previously been determined. By means of ergonomic methods we are able to estimate the oxygen uptake during the work, and then calculate the aerobic work as a percentage of the maximal aerobic capacity of the actual surgeon.

Studies of this kind have been carried out on Norwegian fishermen (Nilsson 1970) and on workers in the steel industry (Nilsson et al. 1970). The present study, carried out in Martina Hansens Hospital in the spring of 1970, included measurements of the oxygen uptake during work, body temperature, loss of water and variations in grip force.

MATERIAL AND METHODS

Four surgeons took part in the study. Their physical characteristics are shown in Table 1. Their maximal aerobic capacity and oxygen uptake on submaximal work loads were analysed in the laboratories of the Institute of Work Physiology in Oslo.

Table 1. Physical characteristics of the test persons.

Surgeon	Age	Weight kg	Max heart rate beats/min	Max. oxygen uptake l/min	ml/kg min
A	60	89	120	2.58	29
B	45	79	175	3.86	48
C	32	77	200	4.40	57
D	27	59	200	3.70	63

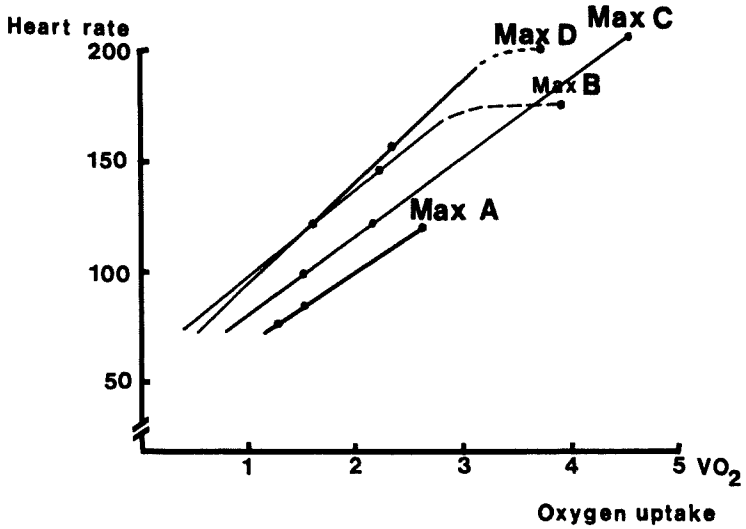

Figure 1. The relationship between heart rate and oxygen uptake at increasing work loads is linear up to near maximum oxygen uptake (Max A-B-C-D). Oxygen uptake (VO_2) is expressed in litre/min. There is one line for each surgeon, and the two tests at submaximal work loads are marked with points at the graphs.

Oxygen Uptake

The maximal aerobic capacity of an individual is defined as the highest consumption of oxygen per time unit during maximal work within a short period of time (Hermansen & Saltin 1969). For this purpose the surgeons were tested on a bicycle ergometer (Monark). In addition to the bicycle test, two were also tested whilst running on a treadmill. Oxygen uptake was determined by the Douglas bag technique. The volume of the expired air was measured in a spirometer, and gas analyses were performed using the Scholander method for determination of its content of O_2 and CO_2 (Scholander 1947).

During activity the heart rate was recorded with a conventional electrocardiographic apparatus. The signals were transmitted from the test persons by telemetry. The cardiogram produced this way could be used in the evaluation of possible heart disorders.

All persons were tested at two submaximal and at maximal work load on the same day. One person was tested at 450 and 600 kpm/min, the remaining three at 600 and 900 kpm/min. (kpm = kilopond meter. 1 kp is the force acting on the mass of 1 kilogram for normal acceleration of gravity). The work periods were 6–8 minutes. The expired air was collected during the last minute in two bags. The heart rate was recorded continuously. The relationship between heart rate and ovygen uptake is shown in Figure 1 a–d. By recording heart rate during work it is possible from these graphs to estimate the oxygen uptake. The actual oxygen uptake can be expressed as a percentage of the maximal oxygen uptake.

During the operation the surgeon's heart rate was recorded telemetrically from

the moment he entered the theatre, one recording being made every 5 minutes. The transmitter is small, and does not disturb the surgeon during work.

Body Temperature

Physical work leads to a rise in body temperature, with extreme activity to more than 39° C. The rectal temperature of the surgeons was measured pre- and postoperatively with a thermocouple mounted in a rubber tube.

Loss of Water

Loss of water by sweating depends on room temperature and the individual tested. Pre- and postoperative weight was noted, and the loss expressed in per cent of initial weight. The scales used were accurate to ± 50 grams.

Grip Force was recorded by means of electronic pressure transducers. Pre- and postoperative values were noted and the difference expressed in per cent of the first value.

RESULTS

A typical heart rate curve recorded from a surgeon doing a Smith-Petersen arthroplasty is shown in Figure 2. The mean heart rate from each operation was calculated, and in the nomogram shown in Figure 1 the mean oxygen uptake was evaluated. Table 2 shows the mean work load on each surgeon during different operations expressed in per cent of maximal aerobic capacity.

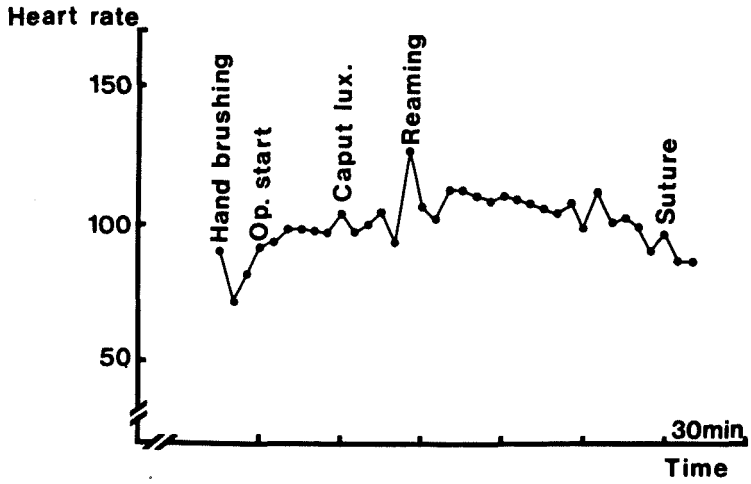

Figure 2. Telemetric recorded heart rate of surgeon B performing a Smith-Petersen arthroplasty. Time difference between each registration is 5 minutes.

Table 2. Mean work load on the surgeon at each operation expressed in per cent of maximal oxygen uptake.

Kind of operation	Surgeon			
	A	B	C	D
Arthrodesis	29	31		
	38	23		
	22			
Osteotomy		25	25	20
		25		20
Operation for lumbar disc herniation	29		21	
			29	
			32	
Menisectomy			11	22
			21	
			19	
Hip arthroplasty		26		
		31		
		41		
Various operations		27	14	22
		23	20	
		27		

Table 3. Mean increase of body temperature per hour.

Surgeon	Increase
A	0.15 ° C/hour
B	0.40 ° C/hour
C	0.33 ° C/hour
D	0.37 ° C/hour

Table 4. Loss of water, per cent of starting weight.

Surgeon	Decrease
A	0.16 per cent per hour
B	0.28 per cent per hour
C	0.07 per cent per hour
D	0.07 per cent per hour

There was an increase in body temperature during every operation. Table 3 shows the mean increase per hour.

Table 4 shows the mean decrease of body weight, reflecting the loss of water by sweating.

Table 5. Variations in grip force of right and left hand compared with duration of the operation.

Surgeon	Number of operations	Mean duration of the operation (min)	Increase or decrease of grip force	
			Right (per cent)	Left (per cent)
A	4	136	— 2.3	— 6
B	9	108	— 1.1	— 1.5
C	8	72	— 3.3	+ 3.5
D	4	75	— 0.9	+ 4.0

Table 5 shows the mean variations in force of the grip, compared with the mean duration of the operation. The variations are small, but seem to show a tendency towards a diminished maximal force with increasing duration of the operation.

DISCUSSION

All surgeons who took part in this study had a relatively high maximal aerobic capacity according to Aastrand & Rodahl (1970). Two of the surgeons were practising physical exercise at least twice a week; the remaining two less frequently.

Surgeon A had an extremely low maximal heart rate (120 beats/min), and in spite of repeated tests it is doubtful whether he had reached his maximal oxygen uptake. Maximum oxygen uptake calculated from heart rate at submaximal work, however, showed an extremely good correlation with the values obtained from gas analyses.

At rest and during minimal physical work psychological factors may influence the heart rate. However, at the work loads described in this study these factors do not interfere with the increase in the heart rate caused by the actual work. The method of recording the oxygen uptake by heart rate as described above has for many years been accepted and used in testing athletes (Aastrand & Roland 1970).

Nilsson (1970) found that Norwegian fishermen during intermittent work achieved 45 per cent of their maximal aerobic capacity. Industrial workers, who considered their work to be too hard, were found to be working at 25 per cent of their capacity during the work periods.

In 24 out of 27 operations, the mean aerobic work load on the surgeons represented approximately 20 to 30 per cent of their maximum aerobic capacity, i.e. in about 90 per cent of all operations. This work

is performed by the large muscles in the arms, but also by the other muscles working statically to maintain the upright position.

Saltin & Hermansen (1966) found that the temperature at all levels of exercise is set according to the relative work load of the individual, and not to the absolute work performed. Nielsen & Nielsen (1964) found a linear relationship between sweat rate and internal temperatures. It is shown that a one per cent decrease of body weight due to loss of water might cause a ten per cent decrease of work capacity (Staff 1971).

The information obtained from this study indicates that the physical work performed by the surgeon during operations will often reach a level where good physical fitness is required. Surgeons should therefore, for the benefit of their patients, and themselves, participate in regular physical exercise.

During prolonged operations loss of body H_2O should regularly be replaced.

SUMMARY

Four surgeons participated in a study which aimed to demonstrate the physical work load during operations. Maximal oxygen uptake and maximum heart rate were determined by using the Douglas bag technique and recording the heart rate during the tests. By working at two submaximal work loads, heart rate was recorded and maximal oxygen uptake was determined indirectly.

Using telemetry, heart rate was recorded during operation, and the mean oxygen uptake was determined. In 90 per cent of all operations the surgeons were working at a level of 20 to 30 per cent of their maximal aerobic capacity.

There was an increase in body temperature and a decrease of body weight after all operations. In long lasting operations a decrease of grip force was noted.

A preliminary report of this study was presented at the 37th Congress of the Scandinavian Orthopaedic Association in Uppsala, Sweden, June 13, 1974.

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