METHODS OF INVESTIGATION OF STATIC ENDURANCE

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The results of investigations of fatigue in industry (182 persons with 9 different occupations) under loads of 0.5 and 0.75 of the maximum strength showed that the index of static endurance (SE) of the hand gives a more reliable result under a load of 0.75 of the maximum strength than one of 0.5 of the maximum strength. However, even if the same quantity of information was obtained from each, a load of 0.75 of the maximum strength is preferred because of the shorter time required for the test.

The results of investigation of 70 persons at a rest home showed that the SE dynamics in persons not at work differs fundamentally from that during shift work; toward evening the SE is actually slightly increased. The decrease in SE toward the end of the working day in industry thus actually reflects the existence of fatigue.

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Determination of the static endurance (SE) is a method of determining the working capacity of the neuromuscular system as well as the subject's volition. Changes in SE can be used as criteria of the dynamics of working capacity and also to assess a particular work and rest program [5, 9]. A number of cases of the successful use of SE as a test of fatigue has been described [3–8]. A regular decrease in SE was observed toward the end of the working day, evidence of the development of fatigue.

The SE is usually determined in industry by the use of a load amounting to 0.5 of the maximum strength. More recently, other loading levels have begun to be used [1, 12].

TABLE 1. Static Endurance with Loads of 0.5 and 0.75 of Maximum Strength

Occupations	No. of subjects	Amount of load strength	Before work		After work		Decrease in endurance, in %
			$M \pm m$	CV	$M \pm m$	CV	
Electrolyzers	10	0,5	93,9±6,0	20,3	67,9±3,6	16,4	27,7
	10	0,75	39,7±4,2	36,0	27,7±2,2	25,3	30,2
Finishers	9	0,5	87,5±4,63	15,9	66,0±5,0	22,8	24,6
	9	0,75	39,7±2,36	17,9	26,1±1,54	17,7	34,2
Engineers	6	0,5	76,7±2,28	10,7	56,1±4,9	31,2	26,2
	6	0,75	37,0±2,11	20,5	23,7±1,69	25,7	35,9
Anodizers	5	0,5	83,4±4,66	12,5	59,4±5,6	21,2	28,7
	5	0,75	29,6±2,22	16,8	19,4±2,05	23,6	34,4
Turners	4	0,5	62,9±6,6	41,9	48,2±3,26	27,0	23,4
	4	0,75	24,8±1,44	23,2	20,8±1,14	22,4	16,1
Joiners	4	0,5	93,0±3,39	12,6	63,5±3,94	27,6	31,7
	4	0,75	30,5±1,6	24,4	24,0±1,61	31,2	21,3
Telephone operators	10	0,5	77,5±7,71	42,2	61,0±3,93	27,4	21,3
	10	0,75	37,3±2,29	26,2	28,7±1,67	29,3	23,0
Scientific research workers	33	0,5	60,2±2,04	19,4	58,6±2,81	27,6	2,6
	33	0,75	29,0±1,8	35,6	23,0±1,38	34,4	20,7
Students	10	0,5	81,9±8,18	32,8	68,2±5,9	27,3	16,7
	10	0,75	34,9±3,18	28,9	27,8±2,53	28,4	20,3
Mean data	91	0,5	76,0±1,61	25,3	60,7±1,29	23,6	20,0
	91	0,75	33,2±0,69	25,0	25,1±0,52	24,7	24,4

Note. Here and in Table 2, CV denotes coefficient of variation (in %).

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TABLE 2. Dynamics of Static Endurance Index Throughout the 24-h Period for Different Groups of Subjects

Group of subjects	Magnitude of load	Indices	Group A						Group B					
			times of measurement (in h)											
			8	12	16	16	20	24	8	12	16	20	24	4
			index of static endurance (in sec)											
Men	0,5 strength	$M \pm m$	72,1±3,9	65,9±3,3	68,7±4,1	75,1±5,4	76,7±4,6	85,7±5,4						
		CV	25,3	23,0	27,2	33,2	27,7	28,8						
	0,75 strength	$M \pm m$	28,2±2,5	28,9±1,8	32,6±2,3	28,4±2,3	32,3±2,3	33,1±1,8	32,3±2,2	29,4±2,1	31,3±2,4	30,9±3,1	33,6±2,4	29,0±1,6
		CV	40,9	28,9	33,0	37,0	32,7	25,5	27,3	28,7	30,5	39,7	27,8	21,3
Women	0,5 strength	$M \pm m$	68,8±3,1	64,8±3,4	67,2±3,4	64,4±2,9	65,2±3,6	76,2±5,1						
		CV	19,8	23,9	21,9	19,4	23,6	28,4						
	0,75 strength	$M \pm m$	28,2±1,9	28,3±1,5	30,8±2,2	31,0±1,8	31,8±2,1	33,2±1,8	30,3±2,8	29,0±2,7	30,4±2,5	30,0±2,4	31,5±2,0	27,0±1,7
		CV	28,8	23,4	31,6	25,6	28,5	23,4	37,4	37,7	32,9	33,0	25,9	24,9

The object of the present investigation was to study whether 0.5 of the maximum strength represents the optimum load, and the effect, if any, of the pattern of shift work on this parameter, and to determine the cause of the decrease in SE observed toward the end of the shift in industry.

EXPERIMENTAL METHOD AND RESULTS

SE was investigated by means of a dynamometer as modified by Rozenblat [11], and by his method [9]. The indicator of the instrument was kept at the level of 0.5 or 0.75 of the maximum strength and with as few fluctuations as possible (fluctuations within the limits of ±5 cm Hg were accepted).

To answer the first question, the SE data during a shift for a series of occupational groups were compared when tested with loads of 0.5 and 0.75 of maximum strength. Investigation of the SE showed a regular decrease in SE for workers in all occupations toward the end of the shift (Table 1). In workers at an aluminum factory (electrolyzers, engineers, anodizers, finishers) the decrease in SE with a load of 0.5 of maximum strength was less than with a load of 0.75 of maximum strength. Results obtained by other methods (radiopulsometry, body temperature, pulmonary ventilation) showed that more objective evidence of fatigue is given by the SE data obtained with a load of 0.75 of the maximum strength. For example, the mean pulse rate obtained by radiopulsometry during the principal work operations varied among electrolyzers from 108.0±1.44 to 148±1.48 beats/min, among engineers from 108.0 ± 2.46 to 141.0 ± 0.68 beats/min, and among anodizers from 108.0±1.85 to 138.0±0.57 beats/min, evidence of the hard nature of the work [10]. Investigations [2] have shown that work during which the decrease in SE by the end of the shift amounts to 32% (or more) of its level before work can be classed as heavy physical work and is characterized by a high degree of fatigue.

The lower percentage decrease in SE with a load of 0.5 of maximum strength can be explained by psychological factors. Since the production process in electrolytic departments is continuous, the workers have to hurry to change places with their opposite numbers leaving from the night shift, and before working they do not always carry out the test up to the limit, thus giving initial values which are too low. Visual observations and interrogation proved that this was so.

Among the turners and joiners, SE was significantly lowered by the end of the shift for a load of 0.5 of maximum strength, not through fatigue, but through the desire to be done as quickly as possible with a time-consuming and tiring experiment. Results obtained by other methods (coordinimetry, reflexometry, pulsometry), and also on persons engaged in heavy work, agreed better with the results of SE tests with a load of 0.75 of maximum strength.

The results of tests carried out on telephone operators at an automatic telephone exchange and on students at universities and colleges showed that the SE index at loads of 0.5 and 0.75 of maximum strength is equally informative (a decrease in SE for telephone operators by 21.3 and 23.0%, and for students by 16.7 and 20.3%). The absence of the psychological factors mentioned above was reflected in the results obtained both before and after work.

The coefficient of variation (CV) ranged between equally wide limits for both types of load.

To answer the second question, SE tests were carried out at a rest home.

Results of the SE tests on 39 persons in group A are aggregated in Table 2. Measurements were carried out 3 times a day, on two days for each type of load (corresponding to the first and second work shifts at the factory). Group B includes the results of tests carried out during the 24-h period on 31 persons. On the first day measurements were made at 8 A.M., 12 noon, and 4 P.M., and on the second day at 8 P.M., midnight, and 4 A.M. (two repetitions).

Changes in SE were observed in both groups, in the absence of any appreciable or regular changes in strength. With a load of 0.5 of maximum strength, a decrease in SE for men and women was observed by midday (mean 7.1%), followed by a slight increase toward 4 P.M. If the value of SE at 4 P.M. is taken as the initial value (beginning of the second shift), in men and women a small increase in SE was observed by 8 P.M. (by 2.1 and 1.3%, respectively), and by midnight (by 13.0 and 18.3%, respectively).

The changes were similar for a load of 0.75 of maximum strength. The initial value of SE (8 A.M.) was the same for both men and women; it remained unchanged at midday, but by 4 P.M. it was increased by a greater degree in the men than in the women. During the evening, SE continued to increase (Table 2).

The view that the decrease in SE observed in industry toward the end of the shift is connected with the diurnal rhythm was not therefore confirmed.

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