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ENDURANCE AND RECOVERY IN REPEATED PERFORMANCE OF STATIC WORK

Investigations of repeated static work have shown that the average »output« increases with decreased load and shortened rest pause between successive efforts.

Introduction

In spite of the great number of researches carried out in order to elucidate the nature and mechanism of fatigue during static work, the problem is still waiting for solution. Two different theories on the mechanism and the locus of fatigue during static work have been proposed. According to one of these theories, fatigue is the result of accumulation of some material in the active muscle tissues which interferes with the maintenance of contraction; according to the other theory, fatigue is due primarly to changes in the nervous system.

Within the frame of these two theories some authors try to relate the mechanism of fatigue to the load under which the static effort is carried out. Some believe that fatigue resulting from light static work is due to peripheral chemical changes, while fatigue caused by heavy static work is due to changes in the nervous centres (K. Wachholder, 1). Others suggest, on the contrary, that fatigue resulting from light static work is due to functional changes in the nervous system, while fatigue in heavy static work is primarily due to a disturbance in the blood supply of active muscles, and only secondarily to functional changes in the nervous system (M. E. Maršak, 2).

In our earlier study (3) we have examined the relation between endurance in static work and the load, and the rate of recovery after a single effort performed under various loads. It was established that the decrease in endurance is faster than the increase of load; thus the »work output« (product of load and endurance time) is highest for light loads and lowest for heavy loads. Within the investigated limits the relation between the load and the »work output« was linear.

By comparing the endurance at two successive trials, separated by a pause of unequal length, we found that there exists a definite difference between the rate of recovery after work under light loads and the rate of recovery after work under heavy loads; the smaller the load under which the work is carried out, the longer is the pause needed for complete recovery.

However, in occupational work we seldom find single static efforts; therefore, in the present study, we have investigated endurance changes in repeated static efforts and the rate of recovery after a series of such trials, varying load, the length of pause, and the number of successive trials.

Methods

Ch. Henry's mercury dynamometer was used. It consists of a vertical glass tube, 130 cm long, open on the top, and ending at the bottom with a rubber bulb, filled with mercury. When the bulb is compressed, the mercury rises. A scale next to the glass tube enables one to read the height of the mercury column. By means of a stop watch the time was measured during which the subject was able to maintain the prescribed pressure. The subject did not know the duration of his performance. The subjects were sitting; the environmental conditions were constant. Special care was taken that the subject grasped the rubber bulb every time in the same manner. To avoid moving or slipping, the fingers were fastened to the bulb by means of a ribbon.

The subject's task was to lift the mercury column to a predetermined height, and keep it at that height as long as he was able to do so. When he was no longer able to maintain the load he released the pressure and after a specified pause he repeated the same task until he reached again the limit of endurance; then followed another pause after which he lifted again the mercury column, and so on. The experiments lasted – according to the length of pause – from 75 minutes to 14 hours. During the rest pauses the subject was allowed to move his fingers back and forth. Each of the two subjects worked both under a heavy and a light load (subject A under 100 and 33.3 cm of mercury, subject B under 70 and 23.3 cm of mercury.*) In a given experiment the rest pauses between successive efforts were of equal length and varied in different experiments from 1 to 150 minutes.

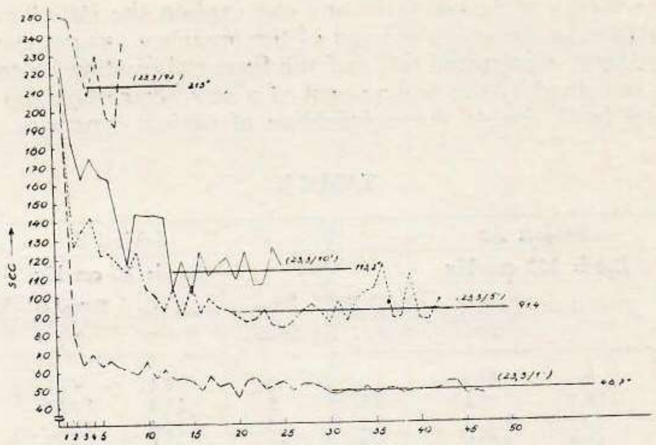
Results

The curves for subject B (Fig. 1) were chosen to illustrate the changes of endurance during successive efforts with fixed rest pauses between these efforts. The ordinate represents the endurance, i. e. the time (in seconds) during which the subject was able to maintain the prescribed

* The load used represents $^3/_4$ and $^1/_4$ of the subjects' maximal grip strength.

load; the abscissa represents the number of successive efforts. On each curve is marked, in brackets, the load (height of mercury column) and the length of the rest pauses.

Sometimes we noticed great variations in endurance, mostly due to the difficulty in grasping the rubber bulb of the dynamometer in entirely the same manner, but still we could draw some conclusions from the values obtained.



the number of efforts →

Fig. 1. Changes of endurance in successive static efforts as a function of the length of pause. The ordinate = endurance time, in seconds; the abscissa = the number of successive efforts. The load and pause for each curve are indicated in brackets. The value attached to the horizontal line indicates endurance at the final plateau. The data were obtained for subject B.

The curves of Fig. 1 suggest that if static work is repeated several times, endurance decreases, the decrease being the faster the shorter is the rest pause between the successive efforts. Owing to this unequal rate of decrease of endurance, the curves show somewhat different shapes. With relatively long rest pauses the curve reminds one frequently of the classic convex ergogram; when the pause is short, the curve is similar to a concave ergogram.

The decrease of endurance time during work is not in direct proportion with the number of efforts. After a shorter or a longer period the decrease of endurance time decelerates and the endurance approaches a stable level with the work continued at the same pace. In other words: *under various loads and with various pauses there is reached a constant level of endurance (the final plateau) which does* *not show any significant change in the course of further work.* In Fig. 1 the final plateaus are marked by a horizontal line at the end of each curve, and next to it the average time (in seconds) is indicated. Thus, for instance, for a load of 23.3 cm and a rest pause of 1 minute, endurance stabilizes on the level of 46.7 seconds.

According to *E. A. Müller* (4), it is possible to account for the final plateau by a balance between fatigue and recovery. But this statement is too general. In our opinion, the attainment of a constant plateau points to *active* changes in functional capacities. In accordance with Cannon's theory of homeostasis, one can explain the initial rapid fall of endurance as the active defense of the organism against exhaustion; the subsequent decelerated fall and the final stabilization of endurance may be explained by the achievement of a new homeostasis, on a lower functional level, due to the mobilisation of various synergies.

TABLE I.

Subject A.				Subject B.			
Load: 100 cm Hg				Load: 70 cm Hg			
Pause in minutes	Final plat. in sec.	Output at final plateau (th)	The average work output $\overline{(th)}$	Pause in minutes	Final plat. in sec.	Output at final plateau (th)	The average work output $\overline{(th)}$
2	9	900	7,0	2	9,4	658	5,1
3	8,5	850	4,5	5	16,4	1.148	3,6
5	10	1.000	3,2	10	18,4	1.288	2,1
10	11,8	1.180	1,9	15	20,1	1.407	1,5
31,3	20,7	2.070	1,1	30	26	1.820	1,0
50	25,5	2.550	0,8				
Load: 33,3 cm Hg				Load: 23,3 cm Hg			
1	36,2	1.205	12,5	1	46,7	1.088	10,2
5	73,3	2.441	6,5	5	91,4	2.130	5,4
20	147,9	4.925	3,7	10	113,2	2.638	3,7
50	214,5	7.143	2,2	30	157,5	3.670	1,9
150	275,3	9.168	0,99	92	213	4.963	0,87

As one could expect, the longer the rest pause between the successive efforts, the higher is the final level on which the endurance stabilizes. However, although the final endurance does rise with the prolongation of pause, it rises more slowly than the pause. If we multiply the value of endurance at the final level (t) by the load (h), we obtain the »work output« (th) which can – at a fixed pause and load – be maintained by the subject practically indefinitely, viz. for several hours. Fig. 2 and table I show the relation between »work output« (th) on the final plateau (ordinate) and the lenght of rest pauses (p) which separate the successive efforts (abscissa). We can see that the »work output« increases slower than the pause (a negative accelerated trend). Consequently, the »average output« ($\overline{th}$, »the output« at the final plateau divided by the time of work plus the pause; $\overline{th} = \frac{th}{t + p}$) is smaller the longer the rest pause (cf. Fig. 3).

As the »average output« represents the optimum which can be obtained during repeated static efforts with a fixed rest pause, it would be of interest to find out how the »average output« under a heavy and

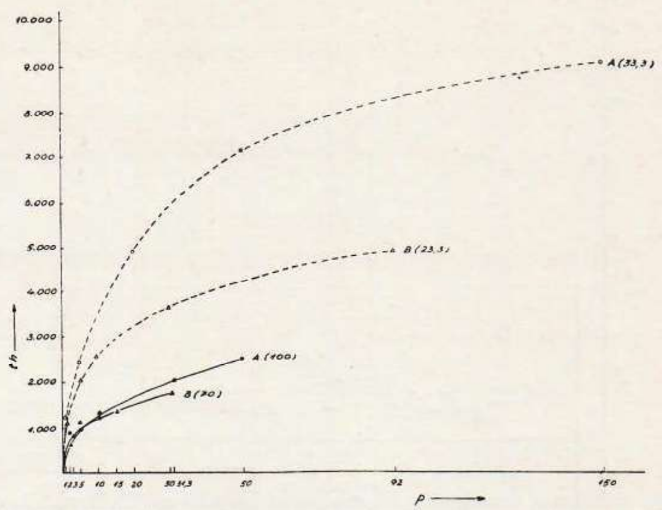


Fig. 2. Relation between the »work output« on the final plateau and the length of the rest pauses. The ordinate = »work output« on the final plateau (th). The abscissa = the length of pause between successive static efforts, in minutes (p). Letters A and B refer to two subjects, the number in the brackets refers to the load (cm of Hg).

a light load depends on the length of pause. The curves in Fig. 3, and table I show these relations. The »average output« ($\overline{th}$) is plotted on the ordinate, and the duration of pause (p) between successive efforts on the abscissa. It becomes obvious that the »average output« under light loads (33.3 and 23.3 cm of mercury) is consistently greater than under heavy loads (100 and 70 cm of mercury). Accordingly, the apparently faster recovery after work carried out only once under heavy load (see 3) cannot – not even on the final plateau – equalize the »output« obtained under a light and a heavy load. Thus if we wish to increase the total »work output« we have to work under light load with as short pauses as possible. An absolutely larger »average output«, at efforts with short pauses, results from the relatively faster recovery in the initial phase of rest and, possibly, also from the fact that static work with short rest pauses approximates dynamic work which can be performed with greater ease.

The number of efforts necessary to reach the final plateau – as a rule – is the greater the shorter the rest pause between the successive efforts (cf. Fig. 1). It is interesting that, in the period preceding the appearence of the final plateau, the endurance does not decrease continuously but it stabilizes temporarily at different levels separated by

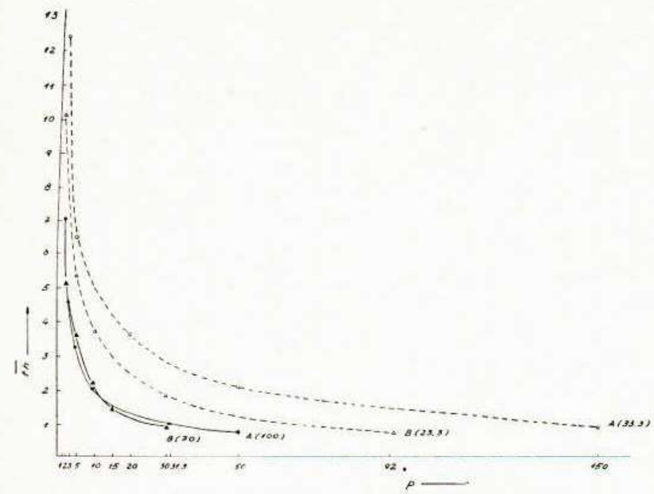


Fig. 3. Relation between the average »work output« and the length of the rest pauses. The ordinate = the average »work output« ($\overline{th}$) (the »work output« on the final plateau divided by the sum of the time of endurance and the length of the pause). The abscissa = the length of pause between successive static efforts, in minutes. Letters A and B refer to two subjects, the number in the brackets refers to the load (cm of Hg).

relatively short and rapid transitions (cf. Fig. 4). These temporary levels become longer and longer in the course of work and the difference between the successive levels diminishes. A curve of the subject B obtained under load of 47 cm of mercury, and with a rest pause of 1 minute illustrates well this point (Fig. 4). The levels and the final plateau are marked in the figure by straight lines parallel to the abscissa.

As these successively levels are more or less masked by random fluctuations, one might object that the identification of these levels is arbitrary and that the obtained values might just as well be represented by a continuous curve. To examine this matter, we have smoothed a great number of curves by the method of moving averages. Although this method of interpolation is not very suitable for our purposes, – since it smoothes not only random but also systematic variations, – it seems to indicate that a discontinuity really does exist. Three curves smoothed in this way may serve as example (Fig. 5).

It is interesting that the subject is aware of the discontinuity. The static efforts are in the beginning very unpleasant and painful, but as soon as the first temporary levelling of endurance is reached, the uneasiness disappears and the static effort is carried on with much less

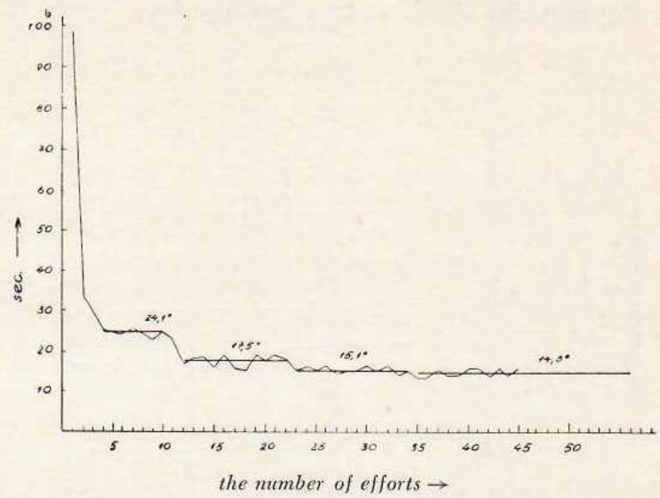


Fig. 4. The discontinuous changes of endurance in the course of successive static efforts. The ordinate = endurance, in seconds. The abscissa = the number of successive static efforts. The horizontal lines indicate the temporary levels of endurance, in seconds. The data were obtained for a load of 47 cm Hg and a rest pause of 1 min.

trouble. This feeling of easiness lasts only as long as the endurance remains stabilized and the feeling of uneasiness appears again with every phase of transition to a new lower level. When the work is carried out on the final plateau the uneasiness disappears and the symptoms of strain are reduced, the perspiration, the hyperemia of the face and the muscular spasms disappear, and the breathing and the pulse rate become almost normal.

The discontinuous decrease of endurance time in the course of successive efforts supports our explanation of the final plateau, and points to the fact that, what may be rather ambiguously termed as fatigue, is a discontinuous process too. In the course of work the organism actively establishes homeostasis and keeps it up until the accumulated effects of muscular activity suddenly force the organism to attain a new balance on a lower functional level. On the basis of changes in the function of various internal organs and the characteristic subjective experiences in the short transition periods, it seems that the realisation of a new homeostasis is accompained by an increase in energy expenditure, and accordingly, in this period, the effort is carried through in a less economic way.

On the basis of the differences between initial endurance and endurance at the final plateau we may determine the degree of recuperation during successive efforts under a fixed load and with a rest pause

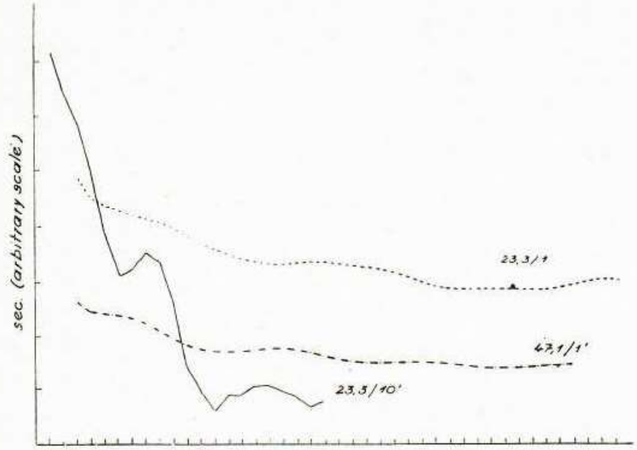


Fig. 5. Three smoothed curves from Fig. 1 and 4. The ordinate = length of efforts (arbitrary scale). The abscissa = the number of successive efforts.

of a certain duration. Such comparisons have shown that the recovery after a series of efforts is considerably slower than after a single effort. Accordingly, the relation between endurance in the first and the second trial can only inadequately indicate the degree of recovery attained in the rest pause inserted between these two efforts. Thus when the load was small (3) in two subjects 150 minutes and 90 minutes were needed for attaining in the second trial the same endurance time as was attained in the first trial. However, if the work is continued at the same rate, endurance decreases. This proves that all traces of fatigue resulting from the first effort have not disappeared. By repeating the work, the traces of fatigue add up and manifest themselves in the shortening of the endurance time. At work under heavy load this difference becomes more marked. Thus, for instance, when a rest pause of 30 and 15 minutes between the first and the second effort was sufficient to attain 100% of the initial endurance, during repeated efforts with the same rest pause, the final plateau amounted only to 64% or 55% of the initial endurance.

On the basis of these facts it seems necessary to revise the general conclusions concerning the rate of recovery which were based only on the comparison between endurance in two successive efforts.

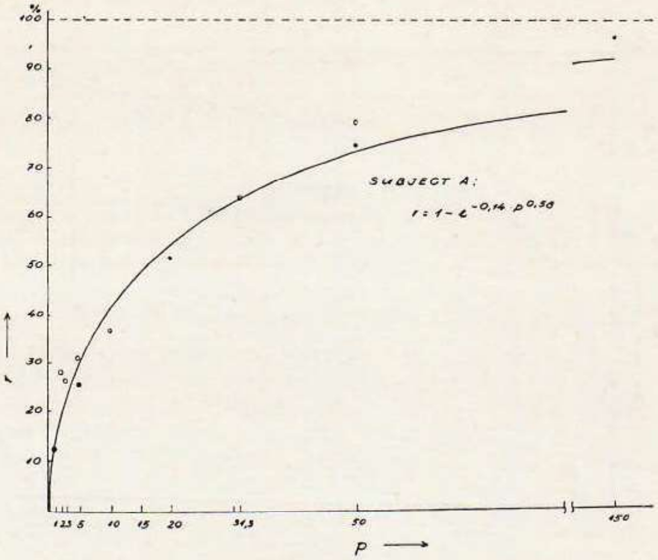


Fig. 6. Degree of residual functional capacity in a series of efforts as the function of the length of pause. The ordinate = the value of the final plateau, in percentage of the initial endurance time (r). The abscissa = the length of the rest pause between successive static efforts (p, in minutes). Results for subject A.

○ = work under 100 cm • = work under 33.3 cm

If we relate the value of the final endurance level, expressed in percentage of the initial endurance time, to the length of the rest pause between successive static efforts, we obtain a curve showing the degree of recovery that is achieved on the final level with a given rest pause. Figs. 6 and 7 and table II represent these relations. The ordinate (r) represents the relative value of the final level, the abscissa (p) the length of pause.

As we can see, with the same rest pause *the relative difference between the initial endurance and the final plateau is similar for work under light or under heavy load.* Consequently, no considerable difference is noticeable in the rate of recovery of functional efficiency under heavy and light load. When we had considered only the first and the second trial (3), the »standard« recovery time, defined as the pause needed to attain in the second trial 95% of initial value, was 4.0 (subject A) and 4.3 times (subject B) longer for a light load than for a heavy load. When the efforts are repeated, the standard level of performance was reached with the same length of rest pause between successive efforts, i. e. 195 (subject A) and 138 (subject B) minutes, under light and heavy loads. Thus *the relative change of the final*

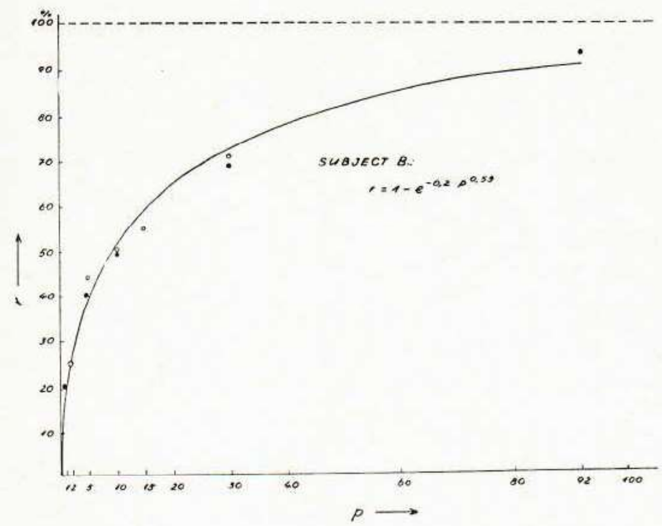


Fig. 7. Degree of residual functional capacity in a series of efforts as the function of the length of pause. The ordinate = the value of the final plateau, in percentage of the initial endurance time (r). The abscissa = the length of the rest pause between successive static efforts (p, in minutes). Results for subject B.

∘ = work under 70 cm • = work under 23.3 cm

plateau depends only on the pause and not on the size of load. As we may see from Figs. 6 and 7 the values obtained for work under heavy and under light load with subject A and subject B are generally on the same curve and we may interpolate them by the exponential equation:

$$r = 1 - e^{-a \cdot p^b}$$

(r is the residual amount of functional efficiency expressed in percentage of the initial capacity, e is the base of natural logarithms, p is the length of pause in minutes, while a and b are constants). The average deviation of experimental values from calculated values, expressed as percentage of the calculated values, amounts to 10.3% for subject A and 5.5% for subject B.

TABLE II.

Subject A.				Subject B.			
Load: 100 cm Hg				Load: 70 cm Hg			
Pause in minutes	Residual capacity (exp.)	Residual capacity (calcul.)	Δ	Pause in minutes	Residual capacity (exp.)	Residual capacity (calcul.)	Δ
2	28,1	19	—9,1	2	25,8	25,5	—0,3
3	26,6	23,3	—3,3	5	44,9	38,5	—6,4
5	31,3	30	—1,3	10	50,4	51	+0,6
10	36,9	41,3	+4,4	15	55,1	59	+3,9
31,3	64,7	64,5	—0,2	30	71,2	72,5	+1,3
50	79,7	74,3	—5,4				
Load: 33,3 cm Hg				Load: 23,3 cm Hg			
1	12,7	13	+0,3	1	20,5	18	—2,5
5	25,7	30	+4,3	5	40,1	38,5	—1,6
20	51,9	54,9	+3,0	10	49,6	51	+1,4
50	75,3	74,3	—1,0	30	69,1	72,5	+3,4
150	96,6	92,2	—4,4	92	93,4	91	—2,4

DISCUSSION

The obtained results may give some indications of the mechanisms of fatigue caused by static work. These include not only an accumulation of metabolites interfering with muscular contractions, i. e. local chemical changes, but also changes in the nervous system.

During any static effort the pyramidal cells in the motor area are active as long as the effort lasts. The greater the static effort, the greater is the activity of the pyramidal cells, reflected in the frequency of the efferent impulses. The intensive and incessant discharge of these cortical motor neurons sooner or later leads to a change in their own activity, i. e. it brings about a decline in the frequency of discharge. The decline in frequency of cortical motor impulses reduces, on one hand, the number of activated lower motor neurons and, on the other hand, it reduces the impulse frequencies from the still active lower neurons. As the intensity of muscular contractions depends on the number of active motor neurons and on the frequency of impulses which reach the muscles, any change in the function of motor cortex cells is reflected in the intensity of muscular contraction as well.

For *heavy loads,* which can be maintained only by a simultaneous activation of practically all muscle fibres of certain muscle groups, the frequency of efferent impulses from the centre is necessarily high, and this leads to a relatively rapid decrease in the functional efficiency of motor centres. Almost all muscle fibres are engaged in such intensive contractions; hence, even a small decrease in the frequency of nervous impulses will inactivate the least sensitive fibres and thus make the maintenance of effort on the given level impossible.

In addition, in static efforts under heavy load there takes place an intensive stimulation of various receptors, particularly in skin and muscles, owing to the intensive contractions of muscle fibres and the strong compression of tissues. The intensive bombardment of the sensory cortical area by afferent impulses can cause central inhibition which also reduces the excitability of the psychomotor area. Furthermore, owing to a high frequency of efferent impulses, some changes in neuromuscular synapses develop during static effort under heavy load; these changes – as it was shown also by *E. C. Pozo* (5) – lead to the so - called *transmission fatigue.* According to *A. Rosenbleuth* and *J. V. Luco*'s (6) investigations the amount of acetylcholine in neuromuscular junctions diminishes at a high frequency of impulses; as soon as the amount of acetylcholine falls below threshold, the impulses can no longer pass from the nerve fibres to the muscles. Also, changes develop in the time constants of reactive tissue (subordinational chronaxy of mucles), owing to changes in nervous centres. Finally, the afferent impulses of high frequency weaken the adaptative–trophic influence of the sympaticus on the muscle tissue.

Accordingly, it is probable, that fatigue which develops in the course of *only one* trial of static work *under heavy load is primarily conditioned by neurophysiological changes,* and only secondarily by the accumulation of metabolites in muscle tissue itself.

The following facts support such a view: (1) the fatigue appears suddenly and the work is interrupted abruptly; (2) the dissipation of fatigue is rapid; (3) immediately after the interruption of the work the previously contracted muscles show normal elasticity and no persistence of contractions is noticeable; and (4) the previously active muscles have normal sensitivity to pressure.

While the fatigue during static work under heavy loads is mostly, or exclusively, of nervous nature, fatigue which develops during a *single* static effort *under light loads* is probably conditioned by chemical and nervous changes.

Firstly, the frequency of discharge from cortical neurons is slower in weaker muscular contractions, and the muscle and skin receptors –

at least in the first phase of such static effort – receive weak stimuli. Owing to the weak activity of nervous centres the number of simultaneously contracted muscle fibres is small; thus during a »continuous« static work the alternation of active fibres is possible. But since the work under light loads lasts for a relatively long time, the products of an increased metabolism may gradually accumulate and lead to local chemical changes which more and more hinder the contraction of muscle fibres. These changes, localised in the beginning on the periphery, cause after a certain time changes in the centres as well. The functional efficiency of mucles has diminished owing to the long action of metabolites; therefore, to maintain the intensity of contractions a greater and greater voluntary effort is needed, i. e. the activity of cortical motor neurons must increase. Besides, after some time the peripheral chemical changes in muscles sensibilize or directly stimulate the sensory receptors, principally the muscle spindles and the algoreceptors; this results in an increased bombardment of cortex by afferent impulses and can lead to the rising inhibition of motor areas. Finally, the metabolites are also transported by the blood and may influence directly the function of centres. When all these interrelated changes reach a certain critical intensity, the static effort must be stopped. Accordingly, *during a single performance of static work under lighter loads the changes leading to fatigue are in the beginning almost completely local and chemical; later these chemical changes lead also to disturbances in the function of centres controlling the muscular activity.*

The above statements agree with the following facts:

(1) A relatively slow development of fatigue; (2) a long period of recovery; (3) a persisting muscular contraction after work; (4) a persisting pain and hyperaesthesia in previously active muscle groups.

Although both the chemical (peripheral) changes and the modifications in the nervous system participate in the etiology of fatigue which follows static work, their share is different depending on the load under which the effort was carried out. At a great load the share of the nervous component in fatigue is dominant, while under light loads the fatigue is preponderantly conditioned by peripheral chemical changes.

When *static work is repeated* the situation seems to be different. The successive efforts lead to the summation of peripheral chemical changes and in this way, the peripheral commponent of fatigue becomes dominant in prolonged work under light load as well as in work under heavy load. This explains the absence of differences in the rate of recovery after a series of efforts carried out under heavy or light loads.

SUMMARY

Changes of endurance in static work and the rate of recovery after a series of efforts were investigated by means of Henry's mercury dynamometer.

(1) When static work is repeated, with an equal pause between successive trials, the endurance decreases the faster, the shorter is the pause between the efforts. This decrease later slows down and finally the performance stabilizes on a constant level which does not change in the further course of work. This constant level – the final plateau – is the result of an equilibrium reached in the course of work.

(2) In the course of successive efforts the endurance does not decrease continuously but stabilizes temporarily on lower and lower levels. The transitions are short and rapid and are accompanied by subjective difficulties. This discontinual changing of endurance proves that in the course of work the organism reaches a temporary equilibrium at various functional levels, and that fatigue manifests itself, in the first place, in a disturbance of the temporary equilibrium.

(3) The level on which the endurance finally stabilizes is the greater the longer the pause between successive efforts, but the final plateau rises more slowly than the increase of the rest pause.

(4) If we divide the »work output« on final plateau by the sum of the endurance time and the pause, we obtain the »average work output«. This value represents the optimum of what may be reached during static efforts carried out at a certain pace. Owing to a progressively slower and slower increase of »work output« with increasing length of the pause, the »average work output« is the greater the shorter the pause between successive efforts.

(5) On the basis of the relation between the initial endurance and the endurance on the final plateau, we may determine the residual functional capacity with reference to pause and load. Such comparisons have shown that, when the rest pauses between successive efforts are prolonged, the functional capacity increases with negative acceleration and this increase is equal for work under heavy and under light loads.

(6) Taking into account the results of the present and of some earlier investigations (3), the authors are of the opinion that fatigue developed during a single static effort under heavy load is conditioned by functional changes in the nervous centres. Chemical changes in muscles play only a secondary role. On the other hand, fatigue developed during a single static effort under light load is thought to be an effect of local chemical changes which are followed by nervous disturbances.

(7) Repeated efforts under heavy loads gradually lead to peripheral accumulation of metabolites; thus the peripheral component of fatigue becomes dominant also in this kind of work. It is for this reason that the differences in the rate of reestablishment of functional capacities at work under light and under heavy load disappear.

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SADRŽAJ

IZDRŽLJIVOST I OPORAVLJANJE U TOKU SUKCESIVNIH STATIČNIH NAPORA

Ispitivanje promjena, koje nastaju u statičnoj izdržljivosti kad se statični napor ponavlja više puta određenim tempom, dalo je ove rezultate:

1. U toku sukcesivnih napora, od kojih se svaki vrši do granice izdržljivosti, izdržljivost se smanjuje, i to tım naglije, što je odmor među sukcesivnim naporima kraći. Pad izdržljivosti nije kontinuiran, nego se trajanje napora povremeno ustaljuje na različitim razinama, koje su među sobom odijeljene relativno kratkim i naglim prelazima. Nakon većeg ili manjeg broja napora izdržljivost se konačno ustaljuje na nekoj određenoj vrijednosti, koja se više ne mijenja, iako se rad nastavlja. Ta konstantna razina (definitivni plato) dostiže se to brže, što je odmor među sukcesivnim naporima duži.

2. Razina, na kojoj se izdržljivost definitivno ustaljuje, raste s dužinom odmora, ali sporije od njega. Zbog toga je prosječni radni učinak (umnožak opterećenja i izdržljivosti na platou, podijeljen s vremenom izdržljivosti i trajanjem odmora) manji uz duže odmore, nego uz kraće.

3. Prosječni radni učinak, postignut pri radu uz nisko opterećenje, veći je i na definitivnom platou od onog, koji se postiže uz visoko opterećenje. Ta razlika među radnim učincima uz različito opterećenje, manja je nego kod jednokratnih statičnih

napora, ali je ipak značajna, što ukazuje, da prividno brže oporavljanje nakon jednokratnog statičnog napora izvršenog uz visoko opterećenje ne može potpuno kompenzirati faktore, koji uvjetuju, da radni učinak opada s opterećenjem.

4. Odnos između početne izdržljivosti (trajanje prvog napora) i izdržljivosti na definitivnom platou ukazuje, koliko je radne sposobnosti sačuvano u toku rada uz određene odmore. S porastom odmora među sukcesivnim naporima raste i količina sačuvanih radnih sposobnosti. Taj porast slijedi krivulju negativne akceleracije, a jednak je i po količini i po brzini pri radu uz visoko i pri radu uz nisko opterećenje.

Prema mišljenju autora, dobiveni rezultati potvrđuju njihovu raniju zamisao, po kojoj bi umor, koji se naglo razvija pri radu uz visoko opterećenje bio u prvom redu uvjetovan promjenama u živčanom sustavu, dok bi umor pri radu uz nisko opterećenje bio pretežno izazvan lokalno-kemijskim promjenama u mišićima.

Kad se statični napor ponavlja, prilike su utoliko drukčije, što i pri radu uz visoko opterećenje dolazi do postepenog gomilanja metabolita u mišićima, tako da periferna komponenta umora postaje i pri radu te vrste dominantna. Zbog takvog izjednačenja u osnovnom mehanizmu, nema više razlike u djelovanju odmora na količinu sačuvanih radnih sposobnosti pri radu uz visoko i pri radu uz nisko opterećenje.

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