SOME REMÁRKS RELATING TO THE TECHNIQUE OF INTERPRETATION OF PLETHYSMOGRAPHIC DATA

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In this paper we present some remarks, of a methodolgoical nature, on the interpretation of plethysmographic data, recorded on the simplest and most widely used model, the Mosso-Novitsky plethysmograph. A number of the remarks may also be applicable to other types of the instrument.

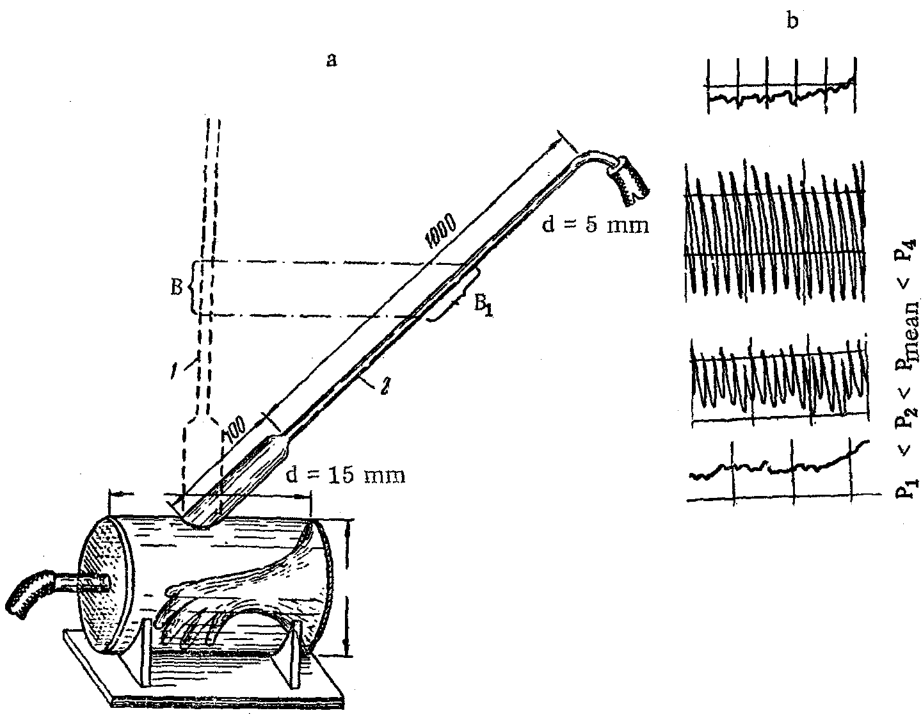

Fig. 1. Schematic representation of a plethysmograph (a), and the amplitude of oscillation at different heights of the column of fluid in the manometric tube of the plethysmograph (b). The ordinates and abscissae are in 1 cm divisions.

Many authors, using the plethysmograph with a constant level of fluid in Tube 1 (Figure 1), find different values for the amplitude of the pulse oscillations in different subjects. Some authors consider the amplitude of the oscillations to be one of the quantitative indicators of vascular tonus. All other factors being equal, the magnitude of these oscillations is a function of the ratio between the external pressure exerted by the column of water in the tube and the internal pressure of the blood in the vessels of the extremity. It will be greatest when the external pressure approaches the average arterial pressure, as is shown by the tracings of Fibure 1, b, in which (from below up) $P_1 < P_2 <$ average $P > P_3$. Following from this, it would seem to us to be more rational to use the instrument at a constant physiological, rather than physical, level, choosing the pressure at which the pulse oscillations are maximum for a given individual, using any other type of plethysmograph. The instrument is under such conditions more sensitive to variations in the volume of the extremity, if the vertical Tube 1 is replaced by Tube 2, inclined at an angle of 30-40° (see Figure 1). Apart from this, with correspondingly equal changes in the volume of an extremity, the latter is less subject to the effect of the external pressure exerted by the column of water.

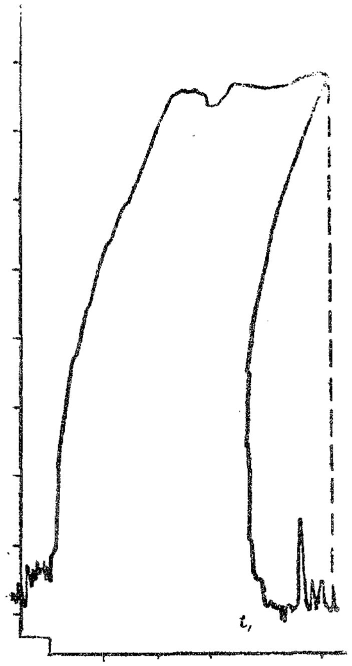

Fig. 2. Movements of the stylus during development of a direct and a return reaction.

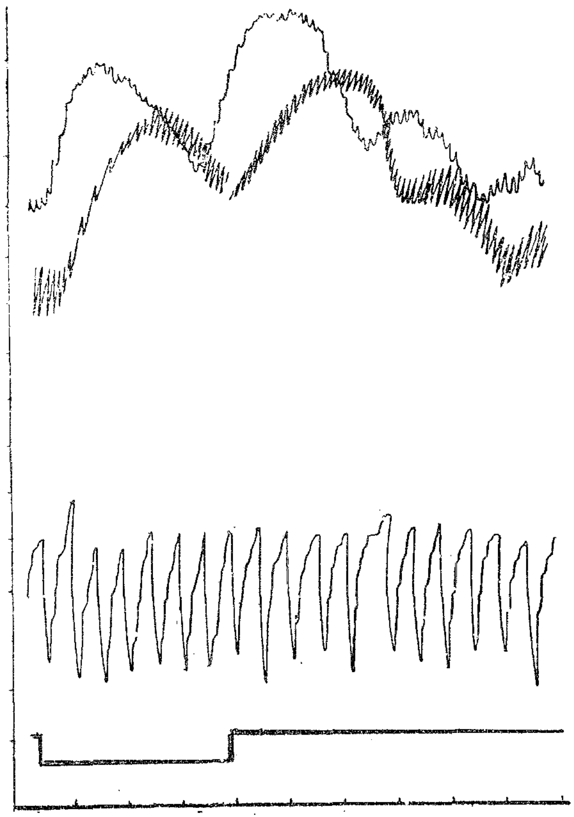

Fig. 3. Example of spurious asymmetry, in the reaction to counting from 20 to 1. Explanation of curves (from above down): plethysmogram, from the left hand, from the right hand, pneumogram, signal showing time and duration of action of the conditioned and unconditional stimuli (the former act over the whole duration of the latter), time signal (5 second intervals). Upward deviations from the initial level indicate, respectively: on the plethysmogram, diminution in volume of the extremity; on the pneumogram, expiration: downward deviations similarly indicate: on the plethysmogram, increase in volume of the extremity; on the pneumogram, inspiration. The graduations of the ordinate axis are each 1 cm, and of the abscissa, 5 second intervals.

In examining a plethysmogram, we pay particular attention to the height of the waves, to their velocity of development, and to the symmetry or lack of symmetry of the reactions. However, plethysmograms do not always give a correct picture of the changes in volume of the extremity concerned. Comparisons of the magnitudes of different reactions are usually based on the amplitude of the fluctuations in volume, without taking into account that the relation between the displacement of the stylus and that of the water in the plethysmograph tube is not a linear one. It is for this reason necessary to calibrate the instrument so as to determine the dependence (expressed graphically) between the displacement of the water level in the plethysmograph tube and the displacement of the stylus. The comparative evaluation of the magnitude of a reaction should be based not on the amplitude of the oscillations seen in the tracings, but on the corresponding changes in the level of the water column in the plethysmograph Tube 2, as derived from the calibration curve. Calibration gives one the possibility of comparing data obtained from different instruments.

The above remarks on the magnitude of the reaction also apply to the speed of development of the direct and return reactions. A precise assessment of the speed of development of a reaction is complicated by the circumstance that the vertical movements of the stylus are along an arc, and not along a straight line (Figure 2). For this reason, the frequently applied method of assessing time as being the point of projection of a curve on the abscissa axis gives an incorrect value; for example, in Figure 2 the return reaction is completed not at time t_1, but at a slightly greater time t_2, the exact evaluation of which requires a knowledge of the rate of displacement of the stylus and of the radius of the arc described by it.

It is evident from the foregoing remarks that the generally accepted procedures for the evaluation of the magnitude and speed of the reactions are not accurate, and require the introduction of corrections.

Since it is not possible to achieve identical tensions of the rubber of the Marey tambours, then, even if the styluses are of identical length and weight (which is in practice highly improbable), the displacements registered on the tracings will be different, although the volume changes in the two extremities may have identical. This gives rise to an apparent difference in the rates of development of the reaction in the two extremities, and to a spurious asymmetry of reaction, applying not only to its magnitude and speed of development but also to its direction at a given moment (Figure 3). This effect is due to one stylus lagging behind the other. It is, in order to establish asymmetry in magnitude and speed of a reaction, essential to switch the recording system over from the left to the right hand, or vice versa. Only then can we speak with assurance of the existence of asymmetry. Asymmetry in the direction of the reactions can be regarded as real only if we are able, visually or otherwise, actually to observe at any moment that the styluses are moving in opposite directions.

The routine registration of plethysmograms from both hands may serve as a reliable method of detecting distortions due to imperfections in the equipment.

In some cases we find that the plethysmograms take a very long time to return to their initial levels, both of the height of the tracing and of the amplitude of the oscillations. Such deviations may be the results of physiological changes connected with the prolonged alteration in the volume of the extremity. Special experiments showed, however, that changes in the volume of the part of the body within the plethysmograph are reflected not only in changes in tension in the receiving tambour, but also partly in the position of the wall of the plethysmograph which is a part of the rubber glove, lined with cotton wool, and bound to the apparatus. Such a wall cannot be considered to be "rigid," and it may often give rise to prolongation of the return of the plethysmogram to its initial level. We apply the following technique to the detection of this possibility. The whole system is connected with the atmosphere. If after this the gradual fall in the level of the tracing continues, the effect is a physiological one, while if it remains more or less constant the effect is of physical origin.

It follows from the above considerations that it is necessary to continue work on the designing of more reliable, although simple, instruments, of a sensitivity adequate for the given purpose, and within the means of a wide range of users.

RECORDING OF ELECTROGRAMS OF WORKMEN DURING INDUSTRIAL WORK

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At present, physiologists studying the physiology of labor register electromyograms (EMG) and electroencephalograms (EEG) of subjects during performance of work under laboratory conditions in screened rooms, whereas electrocardiograms are recorded in the factory itself, using standard techniques, as close as possible to the workplace of the subject.

We undertook the problem of registering ECG and EMG recordings of persons working in industry, simultaneously with recordings of their industrial activities.

Having become acquainted with the techniques of registering bioelectrical activities in the clinic, and of taking the ECG and other bioelectrical records from aircraft pilots in flight (applied in aviation medicine),