SIMPLE CALIBRATION OF ELECTROCARDIOGRAPH SPEED FOR STUDY OF HEART RATE VARIABILITY

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Many of us rely upon the manufacturer's specifications as to paper speed of the electrocardiograph. This is liable to lead to error, sometimes to significant error when accurate measurement of heart rate is necessary. We calibrated four individual battery operated machines of varying age and usage using as an accurate time base the radio signal broadcast from the Rugby transmitter which gave a one second interval pip on a piece of apparatus designed by Hamley (Loughborough University) and Thomason and Samain of this university (1971) whose help is gratefully acknowledged.

Method

A radio receiver gave a variable strength output of the 1 second pip broadcast from MSF Rugby at 60 Kc/sec. (Hamley et al, 1971). The output from this receiver was connected to one channel of an electrocardiograph and a series of fifteen beat traces was recorded in the same manner as that intended for the recording of the radio telemetered data from our subjects. Variations in paper speed were not due to the initial acceleration of the machines as preliminary trials indicated that this period of time was passed quickly.

Statistically, the data were handled by measuring the "signal peak to signal peak" distances in a similar manner to that used when measuring R-R peaks on the ECG, with the values obtained being computed to determine the mean rate per minute, and the variability in the data stated as the mean square successive difference, Von Neumann (1941), and the variance. Confidence bands around the mean at the 95% levels were calculated using the formula $\bar{x} \pm t s$ as described by Ferguson (1959). Information is not to hand on the use of such confidence intervals involving the root mean square successive difference.

Results

The values obtained were treated as R-R values against a published paper speed for each recorder of 25 mm sec⁻¹. As shown in the first row of Table I, a recorder running evenly at the correct speed would provide a mean rate of 60 beats min⁻¹ and zero variability. The actual data from the four machines A, B, C, D is shown in the succeeding rows of the Table, together with the record of determinations, n, from which the statistics in each case were calculated.

Table I

Descriptive statistics of the data

Recorder	Mean R-R mm	n	Mean Heart Rate min ⁻¹	d ²	s ²
Hypothetical Ideal	25.0	—	60.000	0.000	0.000
A	24.6	61	60.886	0.089	0.047
B	24.4	45	61.577	0.070	0.030
C	25.6	45	58.599	0.004	0.002
D	25.0	37	59.982	0.001	0.001

Figure 1 is an example of the type of data obtained from 2 of these machines

MACHINE A

MACHINE D.

Fig. 1. An example of the variability between traces obtained from machines A and D.

The confidence intervals derived from these statistics are shown in Table II.

Table II

95% confidence intervals for the distributions about the mean for each of the four machines, min⁻¹

Recorder	Mean $\pm$ ts R-R mm
A	24.6 $\pm$ 0.434
B	24.4 $\pm$ 0.350
C	25.6 $\pm$ 0.091
D	25.0 $\pm$ 0.065

Discussion

The stability of the paper running speed of electrocardiograph D allowed sensitive observation to be made of heart rate variability. It performed close to the hypothetical 'ideal' constant speed recorder and was also closest to the stated paper speed measured over 15 beats. Recorder C showed variability more than twice that of Recorder D and over 15 beats it ran fastest of all four machines. In comparison to these two, machines A and B were much less stable. The variability in their performance increased by 10 to 20 fold over the performance of machine D. The mean rates over 15 beats also showed some difference from the 'ideal' value.

The effect of these differences in performance is seen in the differences in the confidence intervals within which apparent variability in human data from such apparatus could as well be attributed to variability in the performance of the machine.

From Table II it can be seen that with electrocardiograph D the confidence levels beyond which variability is significant are far lower than machine A.

It might be noted that machine B was comparatively new, from a quality manufacturer, and that the paper speed drive of machine D (by another quality manufacturer) needed attention before satisfactory initial commissioning of the apparatus.

Conclusions

1. Before making assessment of heart rate variability, it is necessary to establish the expected range of random variability in the performance of the recording apparatus.
2. Wide differences in this performance occur between different standard electrocardiographs.
3. Mean running speeds also vary meaningfully between recorders when measures are taken over 15 beats.

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