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Comparison of Motor Activity Measured by Two Different Methods: Optical and Inductive Systems

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Motor activity of twelve rats was recorded by means of two different methods, an optical detection method (ODM) as a mass-independent system and an inductive detection method (IDM) as a mass-dependent system. The chronograms and power spectra obtained from the data were compared to find the essential aspects of both methods. The results suggest that the ODM is more appropriate in studying ultradian rhythms and small motor activity changes, while IDM is better suited to the study of circadian rhythms and gross motor activity variations.

Key words: Inductive detection method, Motor activity, Optical detection method.

In motor activity studies on laboratory animals, several systems such as the open-field (1), wheel-running, optical activity meters, mechanical, or more recently, instruments that use radar based on Doppler effect (3), have all been used.

Obviously, in all these methods, when one studies and discusses the results, the parameter that is actually being measured and the factors on which it depends must be kept in mind. In this way two basic types of methods can be differentiated: a) Methods which are a function of the animal mass (inductive, mechanical) and b) Methods which are independent of the animal mass (open-field, optical, radar, wheel-running).

The aim of this work is to compare two suitable methods for measuring motor activity, namely, an optical detecting method (ODM) that uses crossed infrared beams and an inductive detecting method (IDM). Comparisons are based on a qualitative picture obtained by looking at the motor activity charts especially in the study of the detection of the circadian and ultradian rhythms.

Materials and Methods

Wistar rats, six males and six females, ranging widely in weight from 130-340 were used. At the beginning of the experiment the weights were 182, 193, 210, 230, 280 and 340 g for males and 130, 164, 187, 190, 210, and 280 g for females.

The animals were kept together under a constant temperature (21 ± 1°C), separating the sexes. During the observation period rats were kept isolated in separate transparent Macrolon® cages (size 23 × 23 × 16 cm) with a metal grille floor and a filter paper under it, because other types of bedding could produce accidental interruptions of the infra-red light beams. The observation room was partly sound-proofed. The recording equipment was in a different room. The light was 12L:12D.

For optical detection two units of perpendicular infra-red beams were used. The infra-red emitters were two light emitter diodes TIL 31. Inductive detection was carried out by means of two sensor units (Actisystem®, PB 601).

The TTL impulse counting, coming from the four sensor units, was accomplished by the following elements:

— A two-channel digital counter made in our laboratory, with integrated circuits belonging to the SN74 family.

— Another two-channel digital counter with numerical display (Panlab, type PB 620).

All the counters had BCD numerical codified output which were connected to a programmable multiplexor (Panlab, type 0125). The multiplexor was programmed to print at 15-minute intervals.

To measure the motor activity of one male and one female simultaneously, both detecting methods were used at the same time. Cages were placed in the centre of the corresponding optical detection device, each one being placed on an inductive plate. The observation periods lasted 48 h and the distance between the cages was 70 cm.

The data registered by the printer were recorded on magnetic tape in order to make the subsequent calculations, consisting of harmonical decomposition by means of Fourier analysis using a programmed Tektronix 4051 computer. Subsequently the power spectra were obtained and were also recorded on the same tape. The graphs of motor activity functions and the corresponding power spectra were carried out with a plotter Tektronix 4662.

The ODM and IDM power spectra of each animal were statistically compared by means of the Chi square test, as were the average power spectra for each sex.

The power contents of the second harmonic, obtained from the two different methods described, were compared by the Student's t-test for paired data.

Results

To compare the two methods, the average functions from the six individual motor activity functions obtained using both methods, were plotted. The corresponding power spectra from the males and females were also plotted. Figure 1 shows that there is a similarity between the two motor activity patterns, although the graph corresponding to the optical detection method looks more sharply angled than the one obtained by the inducing method. However, both still show a circadian profile as demonstrated by the superiority of the even harmonics (fig. 2).

It must also be pointed out that the motor activity period (at night) seems to last longer in the graphs corresponding to the ODM, a fact which can be clearly seen in males.

The power spectra also show that, using either method, the fundamental harmonic is the same in both cases, i.e. the one corresponding to a period of 24 h.

In most cases the power content of the fundamental harmonic is higher using the IDM, and lower using the ODM. The difference between the power contents is statistically significant ($p < 0.05$). On the

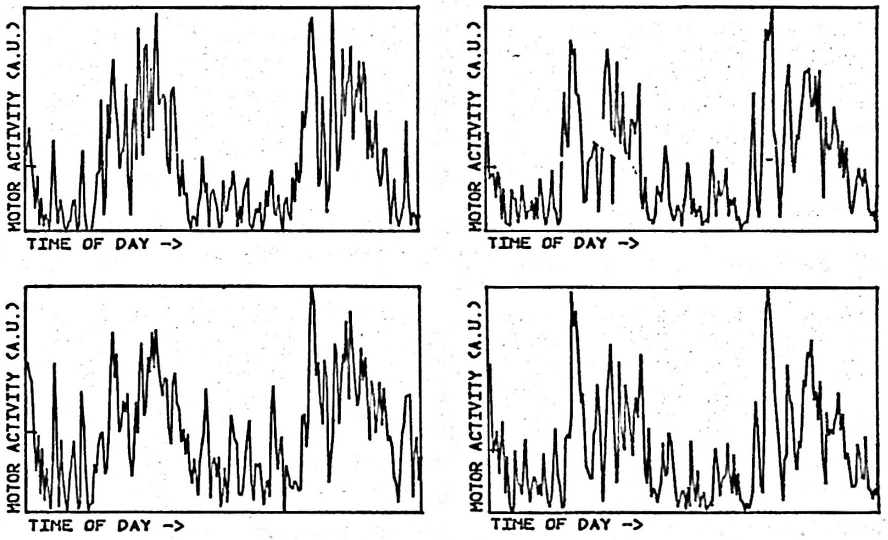

Fig. 1. *Average chronograms of the spontaneous motor activity of the males (on the left) and females (on the right), obtained by means of the IDM (above) and the ODM (below).* The motor activity is represented in arbitrary units. The indicator on the left marks the motor activity average. Each graph corresponds to a 48-hour period.

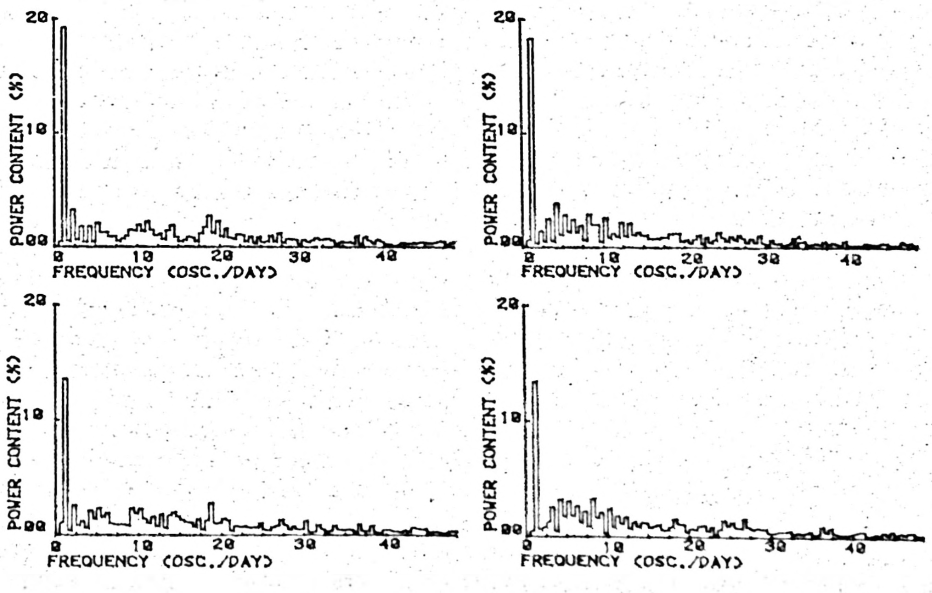

Fig. 2. *Average power spectra of the males (on the left) and females (on the right), obtained by means of the IDM (above) and the ODM (below).*

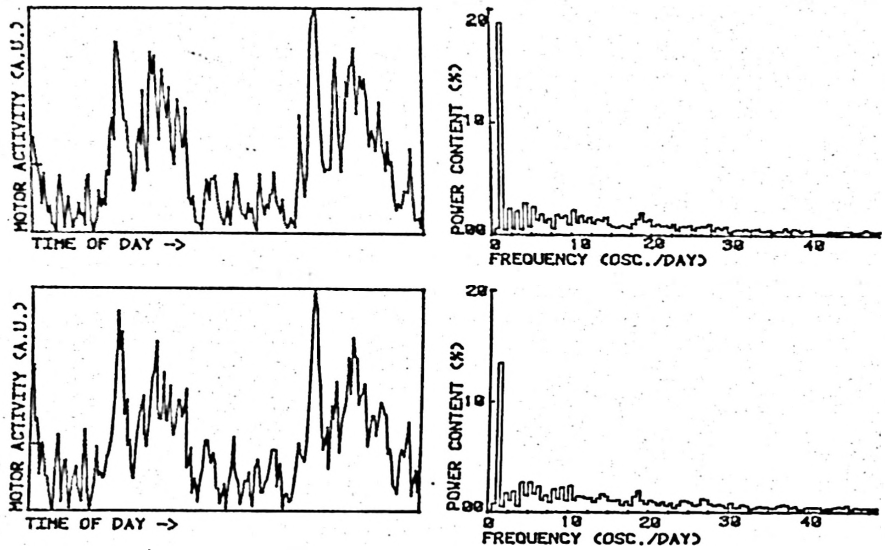

Fig. 3. Average chronograms of the spontaneous motor activity (on the left) and power spectra (on the right) of all the animals, obtained by means of the IDM (above) and the ODM (below).

The motor activity is represented in arbitrary units. The indicator on the left marks the motor activity average. Each chronogram corresponds to a 48-hour period.

other hand, the Chi square test did not show significant differences when it was applied separately to the average power spectra of both male and female. Nor did it show significant differences between the spectra obtained by means of the IDM and ODM ($p > 0.95$).

A fact that is common to all motor activity graphs is the superiority of the power content of the even harmonics over the odd ones. This proves the accurate detection of the circadian rhythm of 24 h within the 48 h period studied. Although this can be observed in both detection systems it is more noticeable when the IDM is used.

Discussion

The aim of this work is to analyze mathematically the motor activity records obtained by the ODM (with crossed infra-red beams) and the IDM, and to establish whether both methods are equivalent. In this discussion the physical parameter that is actually measured to study the animal behaviour is considered. This parameter, in the case of the ODM, is the number of animal movements. This fact is evidenced in the motor activity graph obtained by this method, which shows a more jagged form than that of the IDM graph (fig. 3). The increases in motility recorded during the activity phases of the daily cycle are due both to the increase in the number of movements and an increase in the size of those movements. The latter increase is not detected by the ODM and therefore the use of the IDM seems more appropriate in the detection of circadian rhythms, while the ODM is better suited to the detection of ultradian rhythms. Using the ODM it has been found that the harmonic corresponding to a 24 hour period is 28 % lower than the one obtained using the IDM.

Taking into account that these methods are usually used in screening studies of drugs which modify animal motor activity, we believe that, in order to obtain a good interpretation of the results, it is necessary to know exactly the parameter that is being measured.

In the light of this, in order to compare some behaviour patterns in which the number of the movements (2) are more important than the size of those movements, as in the case of aggressivity tests (4), it seems better to use the ODM.

On the other hand, when the aim is to study phenomena that in some way could be related to the effort or the amount of movements made by the animal, the IDM should be used, as in the case of tests made to detect the general toxic effects of drugs (6), influence of drugs on the CNS or even in studying anti-inflammatory activity (5).

Finally, we suggest that, in pharmacological screening, the motor activity should be measured by both methods, because of the different information that can be obtained by each method.

Resumen

Se registra la actividad motora de doce ratas por medio de dos métodos distintos: método de detección óptica, como sistema independiente de la masa y método de detección inductivo, como sistema dependiente de la masa. Los resultados de los cronogramas y de los espectros de potencia obtenidos, sugieren que el método de detección óptica es más apropiado para el estudio de los ritmos ultradianos y los cambios pequeños de actividad motora, mientras que el método de detección inductivo es preferible para estudiar ritmos circadianos y variaciones amplias de actividad motora.

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