THE RELATIONSHIP BETWEEN BIOCHEMICAL RHYTHMS AND PHYSICAL ACTIVITY & THE EFFECT OF TIME CHANGE

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Although the metabolic response to exercise is well known, it is not generally appreciated that a complex series of biochemical changes take place in the body prior to the day's physical and mental activity. The most important of these involves the adrenal cortex.

Certain biochemical investigations in normal individuals give different results depending on whether the test is carried out in the morning or in the evening. There can be marked differences between the results and often the evening value is outside the 'normal range' established for the morning. This is true for tests of adrenocortical activity. Fig. 1 shows the results of serum cortisol estimations performed, three hourly for 24 hours. Cortisol is one of the important steroids produced by the adrenal cortex. It can be seen that the levels fluctuate, a peak being present at 9.00 a.m. and low levels during the night. This variation is known as a diurnal or circadian rhythm. The diurnal rhythm can also be demonstrated if the metabolites of cortisol (17 - hydroxy-corticosteroids and 17 - ketosteroids) are estimated in urine collected for 6 hour periods.

Experimental work suggests that the diurnal rhythm of adrenocortical activity is under the control of the anterior pituitary gland and hypothalamus althoug the environment is able to influence it through the nervous connections of the cerebral cortex with the hypothalamus.

It is likely that the morning increase in adrenocortical function prepares the body for physical and mental activity for the following reasons:-

1. Adrenocortical activity begins to increase between 3.0 a.m. and 6.0 a.m. i.e. before waking. Therefore the rhythm is not a result of muscular exercise. This contrasts with the creatinine excretion (Fig. 2) which increases with physical activity and therefore is not an endogenous rhythm.
2. Animals which have two periods of spontaneous activity in the 24 hours have increased adrenocortical function preceding each of these periods.
3. There have been many reports showing that there is a diurnal rhythm of muscular efficiency and also in the speed and accuracy of performing various tests and this increases from 9.0 a.m. to 4.0 p.m. before declining at 6.0 p.m. There is loss of efficiency and fatigue if physical exercise is performed outside these hours.
4. The level of adrenocortical activity at night, judged by serum cortisol levels, is similar to that found in patients with underactivity of the adrenal gland. These patients complain of muscular weakness and mental sluggishness and make a rapid and full recovery when given cortisone.

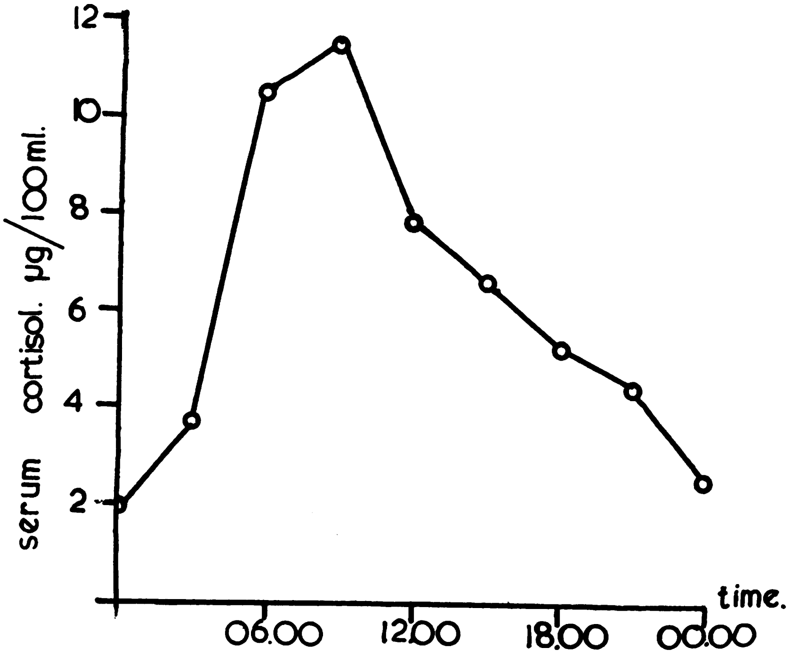

Figure 1. Variation in serum cortisol levels throughout 24 hours.

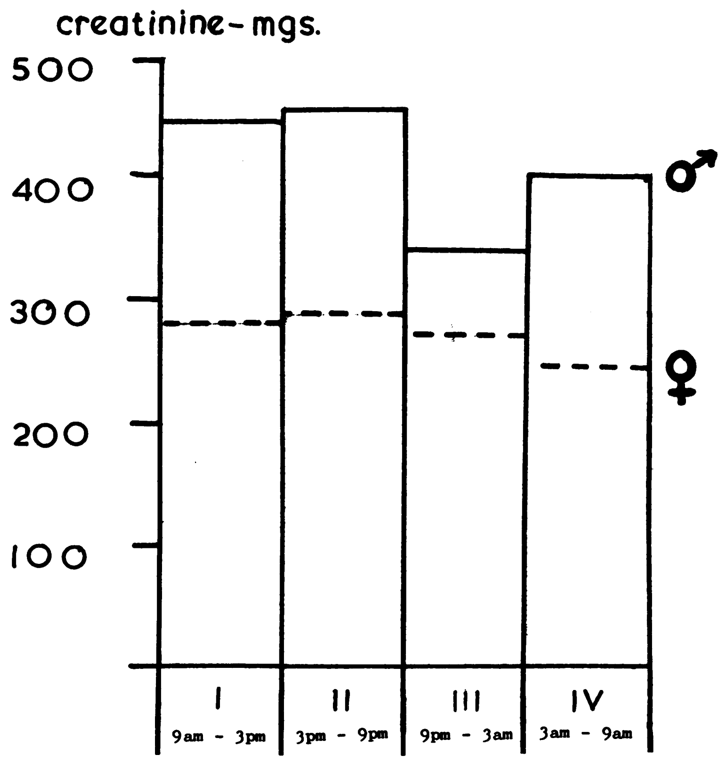

Figure 2. Urinary excretion of creatinine in 6 hourly periods in 20 males (continuous lines) and 20 females (broken lines). Period I, 9.0 a.m.-3.0 p.m.; II, 3.0 p.m. - 9.0 p.m.; III, 9.0 p.m.-3.0 a.m. and IV, 3.0 a.m. - 9.0 a.m.

5. The adrenal cortex controls other metabolic processes some of which one would expect to be of benefit for physical activity, e.g. increased liver and muscle glycogen, blood sugar, glomerular filtration rate, etc.

Therefore, it would appear that the optimal time for physical activity is in the afternoon and this depends on a preceding increase in adrenocortical activity. Conversely, physical activity without preceding adrenocortical activity will result in impaired performance and fatigue. This state of affairs exists when travelling in an East or West direction when the time change establishes a new 24 hour time schedule for sleep and activity. However, the adrenal cortex does not respond to this new time schedule at least not immediately.

If one travels west, the peak of adrenocrotical activity occurs much earlier in relation to the new day and much later if one travels east. To take the extreme example, Auckland requires a 12 hour reversal (from G.M.T.) of the sleep-wakefulness cycle. Therefore any competitive sporting activities performed by teams from this country would be followed rather than preceded by increased adrenocortical function, i.e. when the body is least fitted biochemically for physical activity.

Although the sleep rhythm appears to adjust fairly rapidly to the new time schedule, this is not true for the adrenocortical rhythm judging from reports in the literature. Following an air journey from Minneopolis to Korea (a time change of 9½ hrs.) the adrenal cortex took an average of 11 days for adaptation. Artificial time changing, e.g. in night workers gives similar periods, about 8 to 14 days. In other words, it is likely that teams or individuals competing so far abroad that significant time change is involved (say 6-12 hours) may produce below average performances, unless they have been there for at least 2 weeks.

It would obviously be an advantage for competitors to be in the optimal biochemical state for physical activity otherwise training which improves physiological processes may be wasted. There are several methods of ensuring this in spite of time change, but not all of these are practicable.

1. If a slow method of travel is used, e.g. sailing, the adrenocortical rhythm adapts at the same rate as the time change.
2. Training could be carried out in this country using the time schedule of the country to be visited. This would be suitable for professional boxers, but not for competitors with frequent commitments in this country.
3. Travel to the country where the competition is to be held leaving sufficient time, at least 2 weeks, preferably longer for adaptation of the adrenal cortex to the new time schedule, probably the best method for the Olympic Games. The recommended period of four weeks prior to the projected games at Mexico City is advisable for this aspect of 'acclimatisation' alone.

4. The ideal method for teams with frequent commitments in this country would be to give a physiological dose of cortisone about 8 hours prior to the competition. This is not allowed since it is regarded as doping. However, it is only returning the biochemical status and the performance of an individual to that of the equivalent time in his own country. Furthermore, cortisone probably does not improve performance beyond that produced by the physiological increase in adrenocortical function demonstrated earlier.

'Travel fatigue' can obviously have several causes but one of these may be eliminated if the effects of time change of biochemical rhythms are considered.