A STUDY OF DIURNAL VARIATION IN CIRCULATING EOSINOPHILS ESPECIALLY WITH REFERENCE TO SLEEP IN HEALTHY INDIVIDUALS

KICHIKOSUKE TATAI1 AND SHOKICHI OGAWA2
Department of Physiological Hygiene, Institute of Public Health, Tokyo

It is well accepted from studies on adrenal cortical activity that stressful performance results in hypersecretion sometimes followed by hyposecretion. This physiological manifestation has been called the "adaptation syndrome" (1). Along this line, two investigations were made to demonstrate the special diurnal rhythm in adrenal cortical activity of healthy men; in one of them 17-ketosteroid output in urine was followed throughout the day and night (2), and in the other circulating lymphocyte changes were seen in a successive period of 24 hours.

On the other hand, evidence was obtained that eosinopenia shows a good response to cortisone, a synthetic sugar-active 11-oxygenated corticosteroid which is known as an important product of adrenal cortex (4). Furthermore, Thorn Test based on the eosinophil change has been applied in many hospitals (5). So it was thought worthwhile to show the evidence of diurnal changes in the number of circulating eosinophils which is intimately related to the activity of the sympathetic-adrenal and the pituitary-adrenocortical system (5).

METHOD

First, four healthy young doctors in the Institute were made the subjects of this experiment according to the following schedule: to go to bed and sleep at 11:00 P.M., to wake up at 7:00 A.M., and to work and eat as usual in the daytime. During this 24-hour period, day and night, 0.5 cc. of blood was drawn from the cubital vein every two hours. The blood was immediately oxalated and eosinophils were counted for absolute number by our slight modification of the standard method of Dunger-Thorn (7).

Secondly, two men, both 36 years old, were subjected to do some night work (sampling blood and counting eosinophils for the first experiment) and also to sleep for some hours. The experiment schedule was divided into two groups and the period of sleep for each group was regulated as follows: in one group sleep was continuous for three hours from 12:00 midnight to 3:00 A.M., and in the other it was intermittent but covering the same hours in total, i.e., from 12:00 midnight to 1:00 A.M., from 2:00 A.M. to 3:00 A.M., and from

1 田多井吉之介
2 小川庄吉
Received for publication February 28, 1951.
4:00 A.M. to 5:00 A.M. The circulating eosinophils were counted at eleven o'clock in the evening and at seven o'clock in the morning by the method mentioned above.

RESULTS AND DISCUSSION

In the first experiment, the fall or rise in the number of eosinophils during sleep expressed in percentage of the initial count (at eleven o'clock in the evening) is illustrated in figure 1 for each individual, and that for daytime is shown in figure 2.

Fig. 1. The circulating level of eosinophils of four different individuals during sleep expressed in percentage of the initial counts at eleven o'clock in the evening.

Fig. 2. The circulating level of eosinophils of four different individuals during daytime expressed in percentage of the initial counts at nine o'clock in the morning.
The average value is plotted in figure 3 which shows the general trend that the circulating eosinophils gradually increase after falling asleep with their maximal value in the sixth hour of sleep. After five o'clock in the morning, the circulating level of eosinophils seems to fall rapidly, and to attain the minimal value between eleven o'clock in the morning and five o'clock in the afternoon. We see, therefore, a trend of change in eosinophil counts with a 24-hour cycle, although there are certain individual differences as shown in figure 1 and 2. This diurnal rhythm completely coincides with that of circulating lymphocytes as well as 17-ketosteroids in urine due to the stressful performance in daily routine (2, 3).

As regards individual difference during sleep between subject A. and O., the maximal value in one was between one and three o'clock, while in the other it was at seven o'clock in the morning. If we take into consideration the fact that the one is accustomed to go to bed at ten o'clock whereas the other usually goes to bed at one o'clock, the difference seems to be pretty well explainable as results of their routine habits in sleep. Moreover, taking into account the result that the peak of circulating eosinophils was obtained at the sixth hour of sleep on the average, it is natural to conclude that more than six hours are commonly required for a perfect night rest.

In the second experiment, two persons slept for three hours in total, but the quality of sleep was not identical to that mentioned already in the part on method; one group was conditioned to a continuous sleep for three hours, while the other to an intermittent sleep of equal hours in total. The circulating level of eosinophils in the morning expressed in percentage as compared with that in the preceding evening was found to be significantly lower in the case of intermittent sleep than that in continuous sleep ($P < 0.05$; see table 1). From this difference in eosinophil levels, it may be concluded that continuous sleep will be more effective for the recovery from routine stress than intermittent sleep of the same duration in total, as discussed on the eosinophil change by mental strain from a similar standpoint (8, 9). In other words, a continuous sleep may be physiologically necessary for effective and efficient rest. This fact,
Table 1. The circulating level of eosinophils in the morning expressed in percentage after two types of sleep totalling three hours, either continuous or intermittent.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Continuous sleep</th>
<th>Intermittent sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td>K.T.</td>
<td>102</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>86</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>78</td>
<td>64</td>
</tr>
<tr>
<td>S.O.</td>
<td>102</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td>76</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>84</td>
<td>72</td>
</tr>
<tr>
<td>Aver.</td>
<td>88% (P &lt; 0.05)</td>
<td>70%</td>
</tr>
</tbody>
</table>

moreover, should not be neglected in rationalizing night-work hours, especially for effective management of sleeping rooms occupied by night workers.

SUMMARY

The diurnal change in circulating eosinophils was studied in four healthy men in the daily routine of laboratory life. The maximal level was obtained at night during sleep, and the minimal in the daytime. Moreover, individual habit seems to play some part in the diurnal rhythm in eosinophils. The second observation of eosinophils in two men with short duration of sleep at night indicated significantly that a continuous sleep might be required for an efficient recovery from stressful performance.

We are grateful to Prof. Sy. Matuoka, of the Medical School of Tokyo University, for kind encouragement.

REFERENCES