

STUDY OF THE CIRCADIAN RHYTHM OF POTASSIUM AND SODIUM URINE EXCRETION IN SHIFT WORKERS

S. Solakova, P. Chankova

Key-words: circadian rhythm — potassium and sodium urine excretion — shift work — night, day and afternoon shift succession

Shift work requires biological rhythm readjustment in concordance with socially determined regimen of work and rest (1, 2, 4—6). According to certain authors the rhythm of potassium urine excretion belongs to the strictly regulated bioconstants that does not change in cases of disturbances of the natural rhythm of sleep and awakesness (3). There are only scanty data in the literature available about the circadian rhythm of potassium and sodium urine excretion in shift workers. There is, therefore, reason for investigating the diurnal dynamics of the excretion of these electrolytes in workers of successive three-shift regimen of work and rest.

Material and methods

A total of 46 clinically healthy men aged between 28 and 40 years with length of service between 2 and 12 years were examined in our study. They were divided into 3 groups according to the regimen of work and rest and the intervals of examination. Ist — 12 shift workers from the chemical industry on successive shifts, (8 a. m. — 4 p. m.; 4 p. m. — 12 p. m.; 0 h — 8 a. m.). Any workers were examined in 4-hours intervals (10 p. m.; — 2 a. m.; 2—6 a. m.; 6—10 a. m.; 10 a. m. — 2 p. m.; 2—6 p. m.; 6—10 p. m.) during work in day, afternoon and night shift as well as in rest days. IInd — 12 operators in command halls of the thermo-electric power-station — Varna which shifts succeed each other every three days, and 12 operators of the thermo-electric power-station — Devnya which shifts succeed each other every four days. The examinations were performed in 3-hours intervals during work in day, afternoon, and night shift. IIIrd — control persons of the administration-technical personnel with natural rhythm of sleep and awakesness. The examinations were done in 4-hours intervals during two successive days. Urine samples were collected after bladder emptying. In any sample potassium and sodium concentration was determined by using flame photometry. The results for the corresponding time interval were processed according to the method of variation and cosinor analysis.

Results and discussion

Potassium urine excretion has a characteristic diurnal dynamics when control persons are concerned. The minimal levels are found out during the interval between 10 p. m. and 2 a. m. ($1,19 \pm 0,17$ mequiv/h). Since 6 a. m. potassium concentration increases gradually and reaches its maximum in the interval between 10 a. m. and 2. p. m. ($2,37 \pm 0,25$ mequiv/h) that coincides with literature data

Table 1

Circadian rhythms of electrolyte urine excretion

Indexes	Mesor ± mean error	Amplitude	Acrophase	Peak level
Potassium mequiv/h	1,702 ± 0,000	0,501	10 h 36 min a. m.	2,203
Sodium mequiv/h	12,119 ± 0,004	1,381	11 h 49 min a. m.	13,504

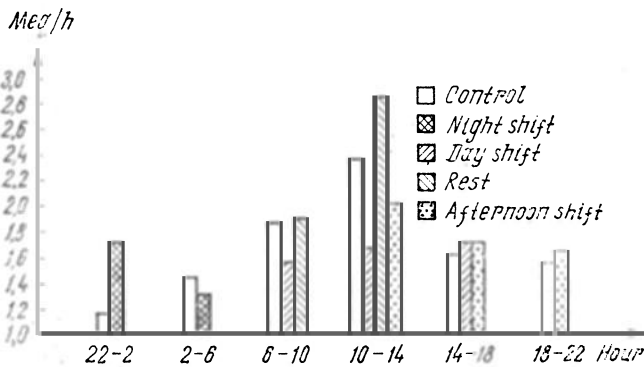


Fig. 1. Daily dynamics of potassium urine excretion in shift workers

(8). Sodium urine excretion is also within minimal ranges in the night (during the interval between 10 p. m. and 2 a. m.) but within maximal ones in the day interval (between 10 a. m. and 2 p. m.) (respectively $9,93 \pm 1,03$, and $14,75 \pm 0,97$ mequiv/h). In contrast to the curve of potassium urine concentration that of sodium demonstrates an increase already during the early morning hours. The processing of the results obtained after the method of cosinor analysis introduced by F. Halberg shows an expressed circadian rhythm of potassium and sodium urine excretion (table 1).

Potassium and sodium urine excretion in shift workers of the first group demonstrates also an expressed circadian rhythm with certain partial abnormalities as compared with that of individuals with natural succession of sleep and wakefulness. There is a relatively lower potassium level in workers in day and night shift (fig. 1). Its minimal values are established during the interval between 2 and 6 a. m. but not between 10 p. m. and 2 a. m. as in the control group. Sodium urine concentration of shift workers is also lower in night and day shift as compared with that of the controls (fig. 2). The retention of both sodium and potassium in the organism is probably an expression of the partial external desynchronization caused by the incoincidence of the external geophysical synchronisators (illumination, air temperature and humidity etc.) and the socially determined requirement to work in the hours of biologically reduced work capacity. It is to be noted that these partial abnormalities of the normal rhythm of electrolyte excretion are temporary and that they restore during the afternoon shift and in rest days. When the examinations were performed during the interval between 10 a. m. and 10 p. m.

in the afternoon shift and rest days as well the almost equal levels as compared with the control ones were found out.

The results of the investigation of the operators in the thermo-electric power-stations show that the term of shift succession and the order of this succession

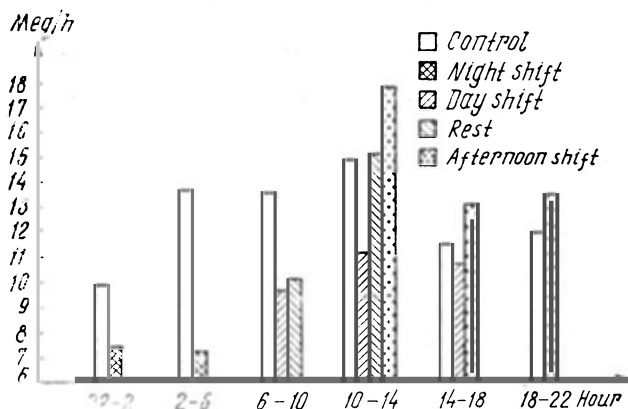


Fig. 2. Daily dynamics of sodium urine excretion in shift workers

influences on the rhythm of sodium and potassium urine excretion. The partial abnormalities in workers on three-days schedule are less expressed than those in workers on four-days one. The latter show potassium concentration of $1,94 \pm 0,2$ mequiv/h in the interval between 0,30 and 3,30 a. m. that is near to the maximal level of the control group. The maximum is reached to the interval between 11,30 a. m. and 3,30 p. m. while it is in the interval between 8 and 11 a. m. when operators on three-days schedule are concerned. Some differences are also observed in the cases of the afternoon shift. Potassium urine concentration of the operators on three-days schedule is near to that of the controls for the intervals studied. It is possible that these differences are determined by the regimen of work and rest. According to some authors (9) organism adaptation to shift work is going on more rapidly if night shift is followed in the schedule by an afternoon but not a day one. In this cases there is a possibility to prolong the sleep thus ensuring an adaptation behaviour in the following hours of awakesness.

Based on our study the following conclusions can be drawn:

1. The principal character of the circadian rhythm of potassium and sodium urine excretion remains in shift workers in spite of partial abnormalities during work in day and night shift.
2. These abnormalities are temporary and reversible. There is a restoration of the circadian rhythms during work in an afternoon shift and rest days as well.
3. The regimen of shift succession influences upon the circadian rhythm of potassium and sodium urine excretion. There are smaller abnormalities when shifts are in three-days schedules as compared with those in four-days ones.

REFERENCES

1. Алякринский, Б. С. Биологические ритмы и организация жизни человека в Космосе. Автореф. дисс. докт. М., 1979. — 2. Далева, М., и др. В: Тр. Междунар. симп. катехоламины и стресс, II. Смоленце (ЧССР), 12—16. IX. 1979 г. — 3. Лобан, М.

Биологические часы. М., 1964, 531—545. — 4. Цанева, Н., Г. Ганчев. *Тр. НИОТПЗ*, 7, 1960, 1—9. — 5. Akerstedt, T., L. Torstval. *Ergonomics*, 24, 1981, No 4, 265—274. — 6. Akerstedt, T., et al. *Sleep*, 5, 1982, S 95-S 106. — 7. Halberg, F., et al. In: *Cellular aspects of biorhythms*. Springer, 1967, 20—48. — 8. Halberg, F. *Amer. Rev. Physiol.*, 31, 1969, 675—725. — 9. Knauth, P. J. Ilmarinen. In: *Experimental studies of shift work*. Westdeutscher Verlag, 1975, 66—73.

ИЗУЧЕНИЕ СУТОЧНОГО РИТМА ЭКСКРЕЦИИ КАЛИЯ И НАТРИЯ С МОЧОЙ У РАБОТАЮЩИХ ПОСМЕННО

С. Солакова, П. Чанкова

РЕЗЮМЕ

Исследовано 46 клинически здоровых мужчин, работающих в химической и энергодобывающей промышленности, а также и контрольная группа административно-технического персонала, работающая активно при нормальном ритме сна и бодрствования. Устанавливается выраженный циркадный ритм удаления калия с мочой (акрофаза отмечается в 10 ч. 36 мин), натрия (акрофаза отмечается в 11 ч. 49 мин.). У работающих посменно наблюдается частичные отклонения от суточного ритма экскреции калия и натрия во время дневной и ночной смен, которые восстанавливаются в дни отдыха и во время послеобеденной смены. Режим труда и отдыха влияет на ритм исследованных электролитов.