Asymmetry of Electrodermal Activity Before and After Transmeridional Airplane Flights

Yu. V. Tornuev and V. E. Pal'chikov

Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 123, No. 4, pp. 391-394, April, 1997
Original article submitted January 10, 1996

The asymmetry of dermal electric potentials and impedance is evaluated in humans before and after long-distance transmeridional airplane flights involving abrupt changes in environmental conditions and work and rest schedules. It is found that temporal variations of asymmetry of these parameters are phasal, occur during adaptation to new environment, and reflect the regulatory role of the central nervous system.

Key Words: *special-shift workers; transmeridional flights; electrodermal activity; asymmetry; interhemispheric relationships*

Evaluation of bilateral functional asymmetry in various systems of the body offers a highly sensitive method for detecting premorbid and morbid states. Of particular value in this respect is analysis of temporal variations in asymmetry [2,4,7]. Previously, we employed bilateral asymmetry of electrodermal activity (EDA) to assess health status of special-shift workers far away from their homes [8,9]. The mechanisms of this asymmetry so far remain unclear. In the present study we examine the asymmetry of electrical activity in relation to concurrently measured physiological parameters in workers.

MATERIALS AND METHODS

The study enrolled two groups of people who traveled by air from Western Ukraine to the Tyumen region (Western Siberia). The first group consisted of 7 men aged 25-45 years who come to the Tyumen region for special-shift work; the second (control) group included 6 men aged 22-29 years who come there for other purposes. Measurements were made twice daily before and after each working day (between 8:00 and 9:00 and 16:00 and 17:00) every day for 15 days in succession, as well as immediately before and after flight. Impedance at low and high frequencies was measured with a portable Tonus-2 two-frequency conductometer [9] using the procedure described previously [5,9]. Electric potentials of the skin were measured with standard nonpolarizing skin electrodes (frequency band 0-0.5 Hz, "right frontal eminence—left arm" and "left frontal eminence—right arm" leads) [8], and the asymmetry coefficients were calculated. The temperature dependence of impedance was evaluated by measuring body temperature with a medical electrothermometer at the site of the impedance electrodes application (the inner surface of the hand). Interhemispheric relationships were assessed by the method of dichotomous audition [10]: acoustic signals (verbal stimuli) were delivered in sequence to the right or left ear, and the results were rated according to the efficiency with which they were recognized and reproduced [2,4]. The EDA parameters were compared with the results of concurrent physiological tests in the same (or similar) group of subjects [1,2,4].

RESULTS

Temporal variations of the asymmetry of EDA parameters and body temperature during a 15-day period of their measurements in the Tyumen region oc-

Laboratory of Physiology and Biophysics, Institute of Regional Pathology and Pathomorphology, Siberian Division of the Russian Academy of Medical Sciences, Novosibirsk

0007-4888/97/0004-0337$18.00

curred in phases and were similar in both groups. There was no statistically significant difference in the asymmetry of EDA parameters before the transmeridional flight; the asymmetry being equal to 4.1%, 2.2%, and 30% for high-frequency impedance, low-frequency impedance, and electric potentials, respectively (baseline values). After the flight, the deviation of the coefficient of asymmetry (K_{as}) of impedance from the baseline value in the control group was significantly lower than in the test group ($p<0.01$) (Fig. 1). After its relative restoration in both groups in the middle of the special-shift period (cycle), EDA asymmetry in the test group increased and remained above baseline until the end of that period, the mean K_{as} values in the evening (after the working day) being higher than in the morning, reaching 10-12% for impedance and 70% for electric potentials of the frontal eminences. The pattern of variation in EDA asymmetry in the control group was similar, but the absolute values of the EDA parameters were lower (by 30% on average). After the subjects of both groups returned to the places of their residence in Western Ukraine, EDA asymmetry values progressively decreased and returned to their baseline levels.

Temporal variations in EDA asymmetry were accompanied by those in the asymmetry of hand temperature. After the flight to the Tyumen region, the deviation of this temperature in the morning from its mean values in the control group lagged behind (at least by 24 h) that in the test group (Fig. 1). No significant intergroup differences in temperature asymmetry were noted in the evening.

A parallel evaluation of interhemispheric relationships demonstrated the presence of a "right ear" syndrome: the percentage reproduction of verbal stimuli delivered to the right ear (left hemisphere) was higher than that recorded for the left ear (right hemisphere), both before the flight (24%) and during the first 2-3 days after it (17.4%), although generalized activation of emotional memory was noted [2]. On the 3rd-4th day of adaptation period, the reproduction of stimuli presented to the left ear was significantly higher than that of stimuli presented to the right ear (25.2% *vs.* 21%; $p<0.05$), indicating domination of the right hemisphere [4]. In the test group, the process started earlier, being accompanied by changes in temperature and being more pronounced than in the control group.

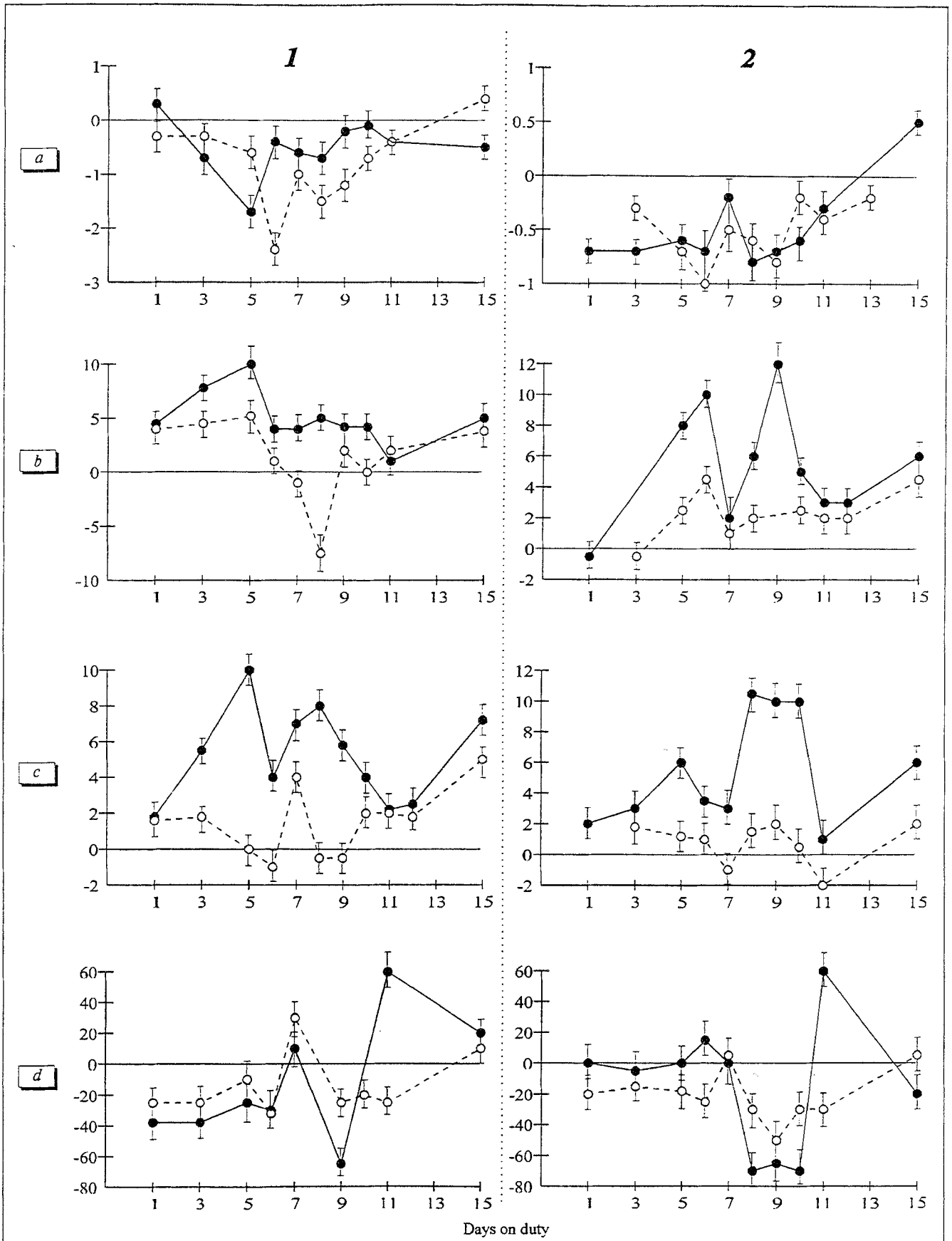
It should be noted that phasic temporal variations in K_{as} of EDA parameters were similar to variations of the absolute values of the corresponding electric parameters as well as to phasic changes in parameters characterizing the functioning of the major bodily systems [3-7]. In our view, this can be taken as evidence that these variations are determined by common mechanisms and are associated with the adaptation of the body to abruptly changed environmental conditions and work and rest schedules, in particular with psychophysiological stress and with phasic changes in the cardiovascular system and bioenergetics [1,3,6,7].

The flight to the Tyumen region from Western Ukraine can be considered as the main factor influencing changes in the studied parameters. Severe environmental conditions of the Tyumen region not only modify psychoemotional reactions and thermoregulation but also dictate the need for adjusting the major rhythms of vital activity to another time zone. This process is usually completed within a 3-4 day period [4,7,8], during the first stage of changes in EDA asymmetry and its relative normalization were observed. The period of adaptation after a long-distance flight is generally associated with activation of the right hemisphere [1,4], which is accompanied by alterations in EDA asymmetry. We attribute the differences between temporal variations in the K_{as} values of high- and low-frequency impedances to a greater contribution of transformations at the tissue and cellular levels to the high-frequency than to the low-frequency impedance [5,9].

An additional evidence for important role of the central nervous system in the formation of EDA asymmetry is provided by the observation that the direction of changes in the EDA of the hands is opposite to that of changes in electric potentials of the frontal eminences when the right hemisphere is activated and the fact that the results of assessment of right-handedness by the parameters characterizing visual and motor analyzers agree with the asymmetry of high-frequency electric conductivity of the epidermis and underlying tissues [8,9].

Abruptly changed environmental conditions and work and rest schedules following a transmeridional flight impair the functioning of the major systems, which alters the interhemispheric relationships. Long-lasting activation of the right hemisphere due to stress caused by special-shift work influences the diencephalic part of the brain [4] and modifies the activity of regulatory systems so that neurological disorders, including arterial hypertension, become possible [4,9]. Such an activation also disturbs natural

Fig. 1. Temporal variations of asymmetry of the electrodermal activity parameters and of hand temperature. Examination times: *1)* 8:00-9:00; *2)* 16:00—17:00. *a)* hand temperature; *b* and *c)* coefficients of asymmetry (K_{as}) of the high- and low-frequency impedances, respectively; *d)* asymmetry of epidermal electrical potentials recorded with leads from frontal eminences and the corresponding hands. Solid line: special-shift worker; broken line: control group. Ordinates: K_{as}, %.


1
2
a
b
c
d
Days on duty

relations between electrical characteristics in the lateral parts of human body, which is reflected by specific temporal variations of EDA asymmetry.

Our results suggest that asymmetry of EDA and physiological parameters during special-shift work is governed by common mechanisms involving the central nervous system.

REFERENCES

1. V. M. Kamenskaya, N. N. Bragina, and T. A. Dobrokhotova, in: *Functional Asymmetry of the Brain, and Adaptation* [in Russian], Moscow (1987), pp. 48-50.
2. V. P. Kolyshkin, *Fiz. Cheloveka*, **9**, No. 2, 195-202 (1983).
3. L. P. Larionov and T. N. Shleeva, in: *Current Topics in the Physiology of Work* [in Russian], Vol. 3, Gorki (1982), pp. 35-36.
4. V. P. Leutin and E. I. Nikolaeva, *Psychophysiological Mechanisms of Adaptation and Functional Asymmetry of the Brain* [in Russian], Novosibirsk (1988).
5. V. E. Pal'chikov, "Two-frequency impedance of human body areas at rest and under functional influences," Author's Synopsis of Dissertation [in Russian], Novosibirsk (1988).
6. S. V. Sokolov, V. V. Osipovich, A. V. Sazykin, *et al.*, in: *Organization of Work for People on Duty During Expeditions: Biomedical Aspects* [in Russian], Tyumen (1980), pp. 100-101.
7. Yu. M. Stepanov, S. V. Shirskii, V. N. Nikolaev, and V. I. Khasnulin, *Ibid.*, pp. 102-103.
8. Yu. V. Tornuev, A. P. Khachatryan, and R. G. Khachatryan, *The Electrical Portrait of Man* [in Russian], Moscow (1990).
9. Yu. V. Tornuev, A. P. Khachatryan, R. G. Khachatryan, *et al.*, *Electrical Impedance of Biological Tissues* [in Russian], Moscow (1990).
10. D. Kimura, *Neuropsychologia*, **4**, 275-285 (1966).