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Postural Influences on the Hormone Level in Healthy Subjects: I. The Cobra Posture and Steroid Hormones

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Abstract—Cortisol, testosterone, dehydroepiandrosterone (DHEA), and aldosterone were measured in the blood serum of healthy subjects who adopted the cobra posture (*bhujangasana*), a key posture of hatha yoga. The subjects were trained in yoga; blood samples were taken before and after the exercise at an interval of no more than 5 min. As revealed with a new confidence interval–evaluating method developed by A.I. Ivanov, cortisol decreased by 11% with a reliability of 0.99 in all subjects, while testosterone increased by 16% with a reliability of 0.95. Changes in DHEA and aldosterone varied. Proceeding from ideas about motor–visceral interactions, the authors hypothesize that, when the subjects adopted the cobra posture, the production of steroid hormones was controlled by neural mechanisms.

Unfortunately, the physiological and therapeutic effects of postural influences are studied on the basis of a relatively limited set of conditionally standard postures. Therefore, other possible spatial positions of the human body do not receive sufficient attention. In particular, of interest to researchers are specific body postures accompanied by a specific pattern of muscle tension. Such postures are called asanas in hatha yoga [1–3]. Studies of the influences of some hatha yoga postures on the systemic [4] and intraorganic blood flow in the liver [5] and kidneys [6] have thrown light on the complex problem of possible rapid hormonal responses to specific postures in healthy subjects. The cobra (*bhujangasana*) posture (figure) specifically influences the intraorganic blood flow in the kidneys and adrenals (a qualitative change in the character of venous outflow) [7]. However, the possible hormonal effects of specific hatha yoga postures have not been studied thus far. Hence, we tried to verify the hypothesis about an influence of the cobra posture on the level of steroid hormones, namely, cortisol, testosterone, dehydroepiandrosterone (DHEA), and aldosterone, in the blood serum of healthy subjects. Our study employed a new

The cobra (*bhujangasana*) posture.

method of finding mathematical models of the distribution of the random values we examined. This method enabled us to analyze the physiological characteristics in small samples.

METHODS

We examined eight healthy subjects, including seven males and one female, aged 22–50 years, who were trained to adopt the cobra posture, a specific posture of hatha yoga. Lying on their abdomens, they bent their spines without leaning on their arms. According to the recommendations of [8], the key condition of adopting the posture correctly is muscular efforts aimed at bending the thoracic part of the spine, which is anatomically slightly flexible. The arms were bent in such a way that the palms lay on the floor at chest level with the fingers stretched forward but without leaning on the floor. Continuing the muscular efforts aimed at maintaining the bend in the thoracolumbar part, the subjects lowered their chins until they felt a sharp increase in the pressure along the line of subjective perception of the kidneys on their backs. Continuously increasing tension of the muscles that take part in maintaining the posture is a substantial element of its technique as the essential condition of appropriate reproducibility of the hormonal changes observed in response to this posture (figure).

The order of actions was the same in all tests. Each subject was examined by a therapeutist, and then a blood sample was taken from the cubital vein of the subject in a sitting position. Thereafter, the subjects lay on their backs for 2 min to attain complete muscular relaxation, which minimized the shift of autonomic indices (heart and breathing rates) caused by blood sampling. Then, the subjects adopted the cobra posture for 2–3 min and blood sampling was repeated. Thus, both procedures took place at an interval of no more than 5 min at exactly 4:00 p.m. (July 2001). The sera were stored at –20°C.

Cortisol and testosterone were quantified in the blood serum by enzyme-linked immunosorbent assay (ELISA) using SteroidIFA-cortisol and SteroidIFA-testosterone kits, respectively. Dehydroepiandrosterone was assayed with a BCM diagnostic kit (United States), and aldosterone, by the standard radioimmune technique.

The hormone levels were measured by the Clinical Diagnostic Laboratory of the St. Petersburg Medical Academy of Postgraduate Studies. The coefficient of variation $k = 8\%$ as a characteristic of the accuracy of our measurements was based on measuring each parameter at least ten times.

RESULTS

To find out whether the cobra posture changes the blood concentrations of hormones, we processed the results mathematically by evaluating the confidence intervals. In other words, we verified the hypothesis that the confidence intervals covering the mathematical expectations of the target continuous random values with a reliability $\gamma \geq 0.95$ did not overlap. The results of measuring blood serum hormone concentrations before and after the cobra posture was adopted are summarized in the table.

If the above hypothesis is true, the change in the blood hormone concentration is significant at $\alpha \leq 0.05$. However, applying common statistical program packages such as STATGRAPHICS, STADIA, Statistica, etc., we obtained results that contradicted our test data. Namely, the pretest cortisol concentration (table, column 2) always exceeded that measured immediately after the test (column 3), which was identified as a casual phenomenon by conventional statistical analysis (for details, see [10]). A similar contradiction was observed in the case of testosterone concentrations measured before and after the exercise (columns 4, 5). Although testosterone increased in all subjects, statistical analysis showed this change to be casual as well.

It has been proven by Ivanov and colleagues that more accurate processing of such results is possible with a new method designed for evaluating changes in the case of small samples and wide scatters of values [11–14], as is characteristic of most contemporary physiological studies.

The new method of mathematical processing of measurements enabled us to calculate the confidence intervals for mathematical expectations of cortisol levels with regard for the aforementioned coefficient of variation $k = 8\%$. Let X_c and Y_c be the mathematical expectations of the pre- and posttest cortisol concentrations, respectively. In our case, the pretest serum cortisol was $X_c = 394.5$ and was covered by the confidence interval $371.9 < X_c < 417.1$ with a reliability $\gamma = 0.95$. A similar calculation of the confidence interval for serum cortisol values measured immediately after the exercise showed that $Y_c = 332.6$ and was covered by the interval $313.6 < Y_c < 351.6$ with a reliability $\gamma = 0.95$. These confidence intervals did not overlap. Calculating the confidence intervals at a reliability $\gamma = 0.99$, we found the confidence intervals $362.1 < X_c < 426.9$ for $X_c = 394.5$ and $305.3 < Y_c < 360.0$ for $Y_c = 332.6$. These confidence intervals also did not overlap. To conclude, it may be asserted with a reliability $\gamma = 0.99$ that blood cortisol decreased after the exercise by 16% on average.

In addition, Ivanov's new method of mathematical processing of measurements became a basis for calculating the confidence intervals of the mathematical expectations of testosterone concentrations at the coefficient of variation $k = 8\%$. Let X_t and Y_t be the mathematical expectations of the pre- and posttest concentrations, respectively. In our case, the pretest value was $X_t = 15.97$ and was covered by the interval $15.0 < X_t < 16.88$ with a reliability $\gamma = 0.95$. A similar calculation of the confidence interval of the posttest blood serum testosterone showed the value to be $Y_t = 18.0$ and to be

Concentrations of steroid hormones before and after adopting the cobra posture

Subject (no., name)	Cortisol, nmol/l		Testosterone, nmol/l		DHEA, ng/ml		Aldosterone, pg/ml	
1	2	3	4	5	6	7	8	9
1. N-in, O.D.	382	284	19.3	22.8	3.2	8.0	221	182
2. N-ov, K.M.	298	253	12.3	12.8	8.0	15.0	70	63.5
3. T-in, S.N.	575	470	23.6	27.2	20.0	9.0	45.9	54
4. S-ev, P.V.	474	382	20.8	21.3	6.4	9.0	175	165
5. Yu-ov, A.N.	318	314	20.6	21.5	12.0	14.0	96.4	62.0
6. O-va, M.Yu.	294	275	0.9*	1.4*	7.4*	5.0*	67.6	55.8
7. M-ev, R.S.	381	293	14.3	19.1	6.0	11.0	11.1	35.5
8. B-ev, A.A.	434	390	–	–	5.8	6.0	103	80.6
Norm [9]	83–441 (at 4:00 p.m.)		Males: 0.52–38.17; * Females: 0.52–2.43		Males: 6.2–43.3; * Females: 4.5–34.0		–	

covered by the interval $16.98 < Y_t < 19.04$ with a reliability $\gamma = 0.95$. These confidence intervals did not intersect. To conclude, it may be asserted with a reliability $\gamma = 0.95$ that the exercise increased blood testosterone by 11% on average.

The results, i.e., a 16% decrease in cortisol and an 11% increase in testosterone on average, differ from the results of calculating the changes in the arithmetic mean because the distribution of our random values was other than normal. Namely, their distribution was a combination of several normal distributions [11, 14].

Measurements of DHEA, an androgen of the adrenal cortex (table, columns 6, 7), and aldosterone, the main mineralocorticoid (columns 8, 9), showed that these parameters changed variously in response to the exercise. DHEA increased in six and decreased in two subjects; the change was considerable (from 20 to 9 ng/ml) in one of them. This makes it necessary to continue the study with a much higher number of trained subjects. The situation with the mineralocorticoid function of the adrenal cortex was similar: aldosterone decreased in six and increased in two subjects; in one of these, the increase was considerable (from 11.1 to 35.5 pg/ml). It is impossible to apply interval evaluation in the mathematical processing of the results obtained with samples of this kind. Therefore, we discuss only the changes in cortisol (a decrease with a reliability $\gamma = 0.99$) and testosterone (an increase with a reliability $\gamma = 0.95$).

DISCUSSION

It is convenient to consider separately the responses of each steroid hormone studied in this work to the cobra posture.

As a rule, various factors (injury, pain, hypoglycemia, exercise stress, infection, emotional shock, etc.) denoted by the general term "stress" increase blood cortisol; this is considered to be a component of adaptive reactions [15]. In this context, many authors have noted an increase in endogenous production of cortisol in response to brief extreme exercise stress [16–18] that is comparable with that experienced in the cobra posture. Factors that increase the cortisol level in healthy subjects include standard postural effects, e.g., when a subject moves from a lying to a standing position (the orthostatic test) [19]. We consider the results obtained by these authors (an increase in cortisol production in response to standard postural effects) as a control for our measurements of the changes in steroid hormones after adoption of the cobra posture.

Notably, the initial serum cortisol values measured in all our subjects were close to the upper limit of the normal range (83–441 nmol/l) found in healthy subjects at 4:00 p.m. [9]. Moreover, initial cortisol slightly exceeded the upper limit in two subjects (474 and 575 nmol/l, table).

Serum cortisol directly decreases in humans only as a result of voluntary muscular relaxation in autogenic training, meditation, etc. [20, 21]. In our subjects, the specific muscle tension caused by the cobra posture significantly (with a reliability $\gamma = 0.99$) decreased serum cortisol. In other words, we observed a paradoxical picture: the cobra posture decreased the cortisol level in spite of a combination of factors (extreme exercise stress and pain caused by blood sampling) that normally increase it.

As for the simultaneous increase in testosterone, the main androgen, it may involve not only the adrenal cortex but also the gonads as the only possible source of an increase in the testosterone level after the cobra posture is adopted [15].

We can only speculate about the mechanisms of these striking changes in production of steroid hormones as a result of the specific muscle tension associated with the cobra posture of hatha yoga. In any case, an influence of the hypophysis seems unlikely since a decrease in blood cortisol, an increase in testosterone, and changes in DHEA and aldosterone took place within less than 5 min; however, this assumption also needs additional verification. Further, in our earlier studies of the effect of this posture [6, 7], neither arterial blood flow from the heart to the kidneys and adrenals nor venous outflow changed quantitatively; this is an argument against an influence of the changes in blood flow on the production of steroid hormones.

It seems more probable that this phenomenon is a result of motor–visceral reflex influences with the participation of autonomic innervation of the adrenal cortex and gonads, beginning from the centers of the spinal cord. The problem of direct nervous influences on the secretion of corticoid hormones is still under discussion as far as the adrenal cortex is concerned. At the same time, the abundant sympathetic and parasympathetic innervation of the testicles and ovaries is considered to be the neural pathway that transmits specific impulses from the hypothalamus to the gonads and supplements the transpituitary pathway [22]. In this context, it is of interest to continue the study of the possible direct nervous control of the secretory functions of some endocrine glands through the mechanisms of motor–visceral reflexes [23]. In our opinion, this phenomenon may be the basis of the hormonal effects of hatha yoga postures.

CONCLUSIONS

(1) The cobra posture, being a particular body position accompanied by a specific muscle tension, leads to a significant decrease in cortisol (with a significance $\alpha \leq 0.01$) and increase in testosterone (with a significance $\alpha \leq 0.05$) in serum of healthy subjects.

(2) In addition, the cobra posture changes the levels of dehydroepiandrosterone and aldosterone, but the changes vary in character.

(3) The cobra posture affects not only the adrenal cortex but also the gonads via motor–visceral reflexes.

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