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EVALUATION OF SYMPATHOADRENAL SYSTEM AND ADRENAL CORTEX FUNCTIONAL ACTIVITY AMONG CHILDREN IN THE AGE AND SEXASPECTS

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Abstract:

The study of relationship between sympathetic-adrenal and pituitary-adrenal systems at the level of the whole organism in ontogenesis is a little-studied problem which has a general biological significance. A comprehensive study of regulatory system functional state of modern schoolchildren will expand the understanding of the neuroendocrine mechanisms of their age development and puberty, which is very important for the scientific foundation of the health care system among younger generation. The aim of research was a comprehensive study of the age and sex characteristics of the sympathetic-adrenal system and the adrenal cortex, the ratio of their functional activity among 10-15 year old boys and girls. The observation among children lasted for 6 years continuously. The content of adrenaline and noradrenaline in daily urine based on fluorimetric method showed the state of the sympathetic-adrenal system. The functional status of the adrenal cortex was assessed by urinary excretion of 17-ketosteroids and 17-oxycorticosteroids using a colorimetric method based on Zimmermann reaction with m-dinitrobenzene and by the reaction with phenylhydrazine after enzymatic hydrolysis (Silber's and Porter's method). The statistical significance of differences was determined by Student's t-criterion.

It was shown that the daily excretion of adrenaline varies slightly among the children of both sexes, while the dynamics of norepinephrine is more pronounced and oscillatory in nature, which is consistent with the concept of chromaffin tissue earlier maturation relative to sympathetic innervation in ontogenesis. At the same time they revealed multidirectional changes in the excretion of 17-ketosteroids and 17-oxycorticosteroids among 11-13 year old boys, reflecting the biological antagonism of androgens and glucocorticoids, which have protein-anabolic and catabolic effects on a body. A certain synchronicity was established in the manifestation of the mediator link functional activity of the sympathetic-adrenal system, androgen and glucocorticoid function of the adrenal cortex,

which is manifested heterochronically in sex groups among 10 - 12 year old girls, and 14-15 year old boys. This confirms the literature data on the presence of close functional relationship between catecholamines and corticosteroids at different levels of neurohumoral regulatory mechanism and shows the features of adaptive reactions of children during prepubertal and pubertal development.

Keywords: Catecholamines, Corticosteroids, 10-15 year old boys and girls.

Introduction

According to the principle of functional system development heterochrony the maturation of neuroendocrine mechanisms takes place at each stage of ontogenesis which are necessary to ensure the vital functions and an optimal adaptation of a body to the conditions of existence peculiar to this age [1]. Nervous and hormonal mechanisms of the sympathetic-adrenal and pituitary-adrenal systems cooperate actively in the starting reactions of a central nervous system level [2], on the stages of catecholamines and corticosteroids biosynthesis in peripheral vegetal ways activity [3,4]. At the same time sympathetic-adrenal system (SAS), its sympathetic part is needed to start the humoral mechanism of adaptive endocrine reactions [5], and the pituitary-adrenal system provides the transition from urgent adaptive responses into the development of long-term adaptation [6]. At that the androgens of adrenal cortex may act as a defense mechanism, reducing the high level of glucocorticoids and the danger of their catabolic effect on the body [7]. The adolescent period of ontogenesis is characterized by the inclusion of complex neuroendocrine mechanisms of puberty, accompanied by physiological hyperfunction of the hypothalamic region of brain and pituitary gland, adrenal cortex and medulla layer [8,9]. The powerful flow of sympathetic impulses in various organs and systems increases the tension and the vulnerability of a child's body when it is exposed to unfavorable external factors. Despite the available literature data devoted to the study of age and sex characteristics of SAS and adrenal cortex (AC) among children and adolescents [10], they are very contradictory, and they were obtained mainly from sick children [11]. There is no doubt that further joint study of regulatory system functional state will expand the idea concerning the neuroendocrine mechanisms of age-related and puberty development of a body from the point of view of the hypothalamic-pituitary-corticomedullary relationship. The understanding of neuro-humoral regulation patterns concerning the adaptive reactions among modern schoolchildren is very important for the scientific foundations of the health care system among younger generation. Based on the abovestated information, the purpose of the study was formulated. This purpose was aimed at a comprehensive study of the age and sex characteristics of SAS and AC, the ratio of their functional activity among 10-15 year old boys and girls.

Methods

10-15 year old boys and girls, studying at a secondary school in Kazan related to I and II health groups took part in the study. 42 girls and 39 boys were selected, they were observed for 6 years continuously.

SAS status was judged by the content of adrenaline (A) and noradrenaline (NA) in daily urine based on fluorimetric method [12]. The collected urine was acidified by sulfuric acid and was kept in a refrigerator. It was adjusted with ammonia to pH - 8.2 in the presence of EDTA before the determination. Standard catecholamines of Sigma company were used during fluorescence measurement. The state of NA was assessed according to the content of 17-ketosteroids (17-KS) and 17 oxycorticosteroid (17-OCS) in daily urine. In order to determine 17-KS the colorimetric method was used based on Zimmermann reaction with m-dinitrobenzene; 17-OCS content was determined by the reaction with phenylhydrazine after enzymatic hydrolysis (Porter's and Silber's method in the modification invented by Yudaev N.A.) [13]. The statistical analysis of the obtained material was carried out by standard methods of variation statistics using the software package Microsoft Excel Windows 2007. In order to assess the reliability of differences T-test was used based on Student's t-criterion.

Results

The analysis of age indicator dynamics concerning the studied systems showed that the functional activity changes in the hormone and mediator SAS links, the androgen and glucocorticoid function of AC observed among children during prepubertal and pubertal periods of ontogenesis, are manifested heterochronically in sex groups (fig. 1,2). Thus, the daily excretion A among the children of both sexes changes insignificantly from 10 to 15 years. There is only its slight increase among the boys at the age of 14, and it makes 0.97 mg/day ($p < 0.05$), which is consistent with the concepts of an earlier chromaffin tissue maturation relatively concerning the sympathetic innervation in ontogenesis [3] and it is consistent with the data about its complete formation among 7-10 year old children [9]. While the dynamics of CA excretion is more pronounced and is oscillatory one, decreasing at the age of 12 - 13 among boys and increasing by 5.38 mg/day at the age of 14 ($p < 0.05$). CA excretion among schoolgirls has its own characteristics - its maximum level was observed at the age of 10, and this does not rule out the increase of pubertal CA, which is revealed earlier than among boys, and makes 3.77 mg/day ($p < 0.05$) at the age of 12. That is, the functional activity of SAS sympathetic component is manifested among girls at an earlier age as compared to boys and their peers surveyed 15-25 years ago [14], which indicates the predominance of nervous regulation mechanisms and is considered more optimal for the maintaining of a long drive for physiological systems in a child's body.

However, the analysis of the relative values for A and AC excretion presented in a previous article [15], reveals their decline from 10 to 15 years (except for 11 year old boys who have a higher rate of AC excretion per 1 kg of body weight than 10 year old ones), explained by the fact that the increase of absolute figures takes place on the background of a body weight significant increase during the prepubertal period and puberty. According to our data, boys have a gradual increase of CA/A ratio when they become older (with some decline in 13 years, when CA excretion is relatively lower), and the largest increase of this ratio takes place at the age of 10 - 12 years. Thus, on the background of SAS links heterochronic maturation the activity of its mediator department increases in both sex groups. The comparative analysis of SAS and CA among children showed a certain synchronism in the manifestation of their functional activity with age, which is most clearly expressed in respect of the sympathetic SAS component and glucocorticoid CA function. Thus, a reliable increase of CA excretion among boys is accompanied at the age of 13 - 14 years by an equally significant increase of 17-OCS daily excretion, which amounts to 1.59 mcm/day ($p < 0.05$) and, on the contrary, these indicators tend to decrease at the age of 12-13 years. Girls have an earlier maturation of mediator SAS link, accompanied by the highest daily excretion of CA at the age of 10, combined with equally significant release of glucocorticoid and androgen metabolites ($p < 0.05$). However, the opposite changes of studied indicators are revealed. Against the background of the progressive and linear increase of 17-OCS boys have the tendency to reduce 17-OCS at the age of 11-13 years. Probably this reflects the biological antagonism of androgens and glucocorticoids that have protein-anabolic and catabolic influence on a body, which shows the growing role of CA androgen and sex glands in the regulation of growth processes with age [11,15], and confirms previous findings about the negative correlation of 17-OCS and a positive relationship of 17-OCS with the indices of body length among the schoolchildren at the age of 11 and 15 years [16].

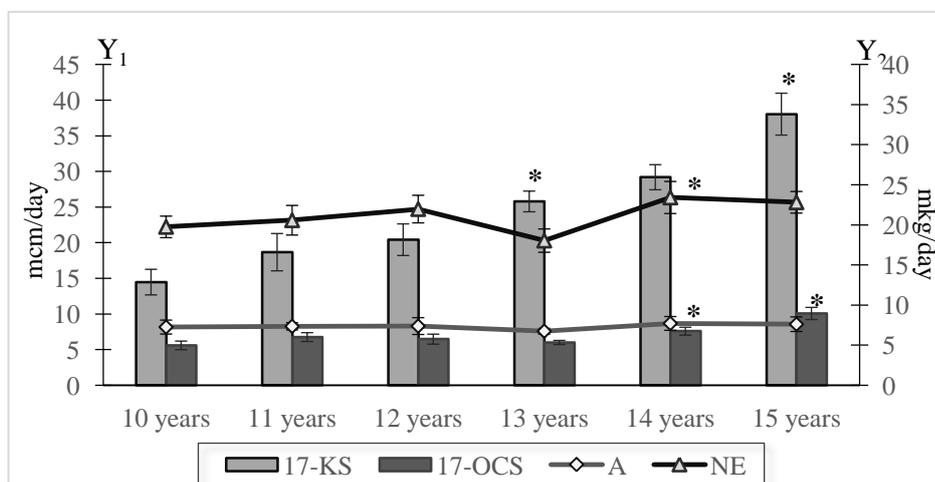


Fig. (1). Age dynamics of catecholamines, metabolites of androgens and glucocorticoids excretion among 10-15 year old boys.

Remark: ordinate - Y_1 – excretion of 17-KS and 17-OCS; Y_2 – excretion of A and NE.

* -differences are significant $atp < 0,05$ in comparison with previous age

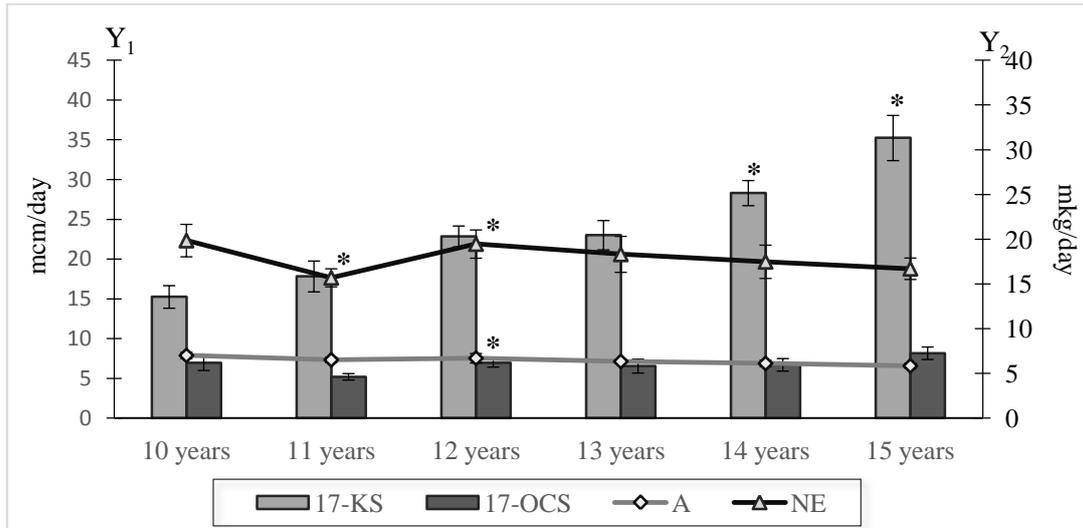


Fig. (2). Age dynamics of catecholamines, metabolites of androgens and glucocorticoid excretion among 10-15 year old girls.

Remark: ordinate - Y_1 – excretion of 17-KS and 17-OCS; Y_2 – excretion of A and NE.

* -differences are significant $atp < 0,05$ in comparison with previous age

Discussion

Thus, this study led to the following conclusions:

1. The age development of SAS and CA among 10-15 year old children occurs heterochronically in age-sex groups: the most significant increase of CA daily excretion is detected among 10 year old girls and 14 year old boys. At that the excretion of A varies slightly in both sex groups; the peak in 17-KS and 17-OCS excretion is observed at the age of 10, 12 and 14, 15 years respectively.

2. The simultaneous increase in absolute figures of CA, 17-KS and 17-OCS daily excretion is observed at the age of 10 among girls and at the age of 14 among boys, at that the dynamics of androgen metabolite excretion and glucocorticoids in the group of adolescents has different vectors at the age of 11-13 years.

The obtained data concerning a more pronounced age dynamics of CA excretion compared A is consistent with the concepts of chromaffin tissue early maturation relative to sympathetic innervation in ontogenesis [3] and is consistent with Drzhevetskaya I.A. (1987) and Selverova N.B. (2009) data on its complete development at the age of 7-10 years. At that the girls as compared with boys and their peers surveyed 15-25 years ago [14], have an earlier manifestation of SAS sympathetic component functional activity, reflecting the predominance of their nervous

regulation mechanisms and it is considered as more optimal for the maintaining of a long-term excitation of a child's body physiological systems. The opposite changes in 17-KS and 17-OKS excretion among the boys at the age from 11-13 years may reflect the biological antagonism of androgens and glucocorticoids which have protein-anabolic and catabolic effect on a body [7,8,16], as well as evidence the growing role of CA androgens and sexual glands in the regulation of growth processes [11]. This is confirmed by earlier obtained data on the negative correlation of 17-OKS and a positive relationship with 17-KS indices of a body length among the schoolboys at the age of 11-14 years [17]. The revealed synchronism of regulatory system functional activity is the most evident one in relation to SAS mediatorlink and CA glucocorticoid function, confirms the data from Duval F. et al. (2000), Nozdrachev A.D. (2001), Brede M. (2003) on the close functional relationship between catecholamines and corticosteroids at different levels of neurohumoral regulatory mechanism.

Thus, the age development and the adaptive activity among 10-15 year old children is provided by complicated, interdependent reactions of SAS and CA, aimed at the meeting of the basic metabolic and adaptation needs of a growing organism. Stating the presence of a certain synchronicity in the manifestation of the regulatory system functional activity, a heterochronic nature of their maturation in age-sex groups is noted. This points to a special role of catecholamines and corticosteroids in the provision of adaptive reaction neuroendocrine mechanisms among children and their more perfect character among girls as compared to the character of boys.

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