Cortisol levels in athletes during their adaptation to physical exercise

UDC 612.817.3+577.175.5.06[-053.5,, 465.11/15,

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Received by the editorial office on 12.01.2026

Abstract

Objective of the study is to investigate cortisol excretion levels in boys aged 11–15 under conditions of increased physical exertion.

Methods and structure of the study. The study involved ice hockey players aged 11–15 and boys from a control group who were undergoing physical training as part of the general school curriculum. The excretion of bound (Cb) and free (Cf) cortisol in urine was studied. The concentration of Cb was determined by chemiluminescent immunoassay on microparticles using the ARCHITECT i optical system (manufactured in the USA). Free cortisol (Cf) was determined using an enzyme-linked immunosorbent assay (ELISA) with the URINARY 'FREE' CORTISOL ELISA (EIA-2989) kit (manufactured in Germany). A functional test in the form of a graded bicycle ergometer exercise test was used.

Results and conclusions. Increased physical exertion is the dominant factor in the development of glucocorticoid function in the adrenal cortex of boys aged 11–15. High values of Cf and Cb in young ice hockey players, exceeding those of boys in the control group, indicate the stressful impact of physical exertion, particularly in the early stages of the training process. A decrease in Cf at the age of 15 against a background of stable Cb values, observed both at rest and following a controlled physical workload, may indicate the formation of a glucocorticoid reserve during training and an increase in children's resistance to increased physical workload with age.

Keywords: *cortisol, adolescents aged 11–15, hockey, adaptive responses.*

Introduction. Cortisol plays a key role in the mechanism by which short-term adaptive responses transition into the full development of long-term adaptation to physical exertion. In doing so, it not only mobilises the body's plastic functions, creating a pool of free amino acids to support the formation of fats and carbohydrates, but also prevents excessive tissue responses to stress through temporary regulatory suppression of hormone synthesis [3]. Of particular importance when assessing the glucocorticoid function of the adrenal cortex (AC) is the separate study of the levels of free and bound cortisol. The transcortin-glucocorticoid complex has no hormonal activity; it serves to transport glucocorticoids to tissues and acts as a rapidly mobilisable reserve [1]. The effect of physical exercise on AC function in children and adolescents has been studied by a number of researchers; however, in most studies, the activity of regulatory systems is considered merely as an indicator of the child's physical fitness, without taking into account age-related characteristics [5, 6]. At the same time, persistently elevated cortisol levels suppress the biosynthesis and secretion of androgens, leading to delayed growth and puberty in children [2, 4]. Therefore, excessive physical exertion can cause serious endocrine and cardiovascular disorders in young athletes.

Objective of the study is to investigate cortisol excretion levels in boys aged 11–15 under conditions of increased physical exertion.

Methods and structure of the study. The study involved 40 ice hockey players aged 11–15 (sports

class) and 38 boys from the control class who were undergoing physical training as part of the general school curriculum. The excretion of free (Cf) and bound (Cb) cortisol in urine was studied. Cb levels were determined by chemiluminescent immunoassay on microparticles using the ARCHITECT i optical system (manufactured in the USA). Cf was determined using an enzyme-linked immunosorbent assay (ELISA) method with the URINARY 'FREE' CORTISOL ELISA (EIA-2989) kit (manufactured in Germany). To assess the reserve capacity of the AC, a graded exercise test was performed on the 'RITM' VE-05 bicycle ergometer for three minutes at a load of 1.5 W per 1 kg of body weight.

Statistical analysis of the data was performed using methods of variational statistics with the Microsoft Excel Windows 2010 software package. To assess the significance of differences, a t-test based on Student's t-criterion was used.

Results of the study and discussion. It was found that daily Cf excretion in athletes aged 12 to 14 years varies only slightly, ranging from 206.01±8.31 to 242.80±14.10 nmol/day, whilst at the age of 15, a significant decrease of 32.77 nmol/day was observed compared with 14-year-olds ($p<0.05$) (see Table). Such age-related dynamics of cortisol levels are inconsistent with the literature data on the patterns of adrenal cortex function development with age [2, 3] and differ from the indicators for boys in the control group, in whom Cf excretion at 12, 13 and 14 years was 1.6–1.9 times lower than that of the athletes ($p < 0.05$), whilst a significant increase was observed from 13 to 14 and 15 years.

It was further established that the levels of Cf and Cb in young ice hockey players change in opposite directions with age – against a background of a decrease in Cf from 14 to 15 years of age, consistently high values of Cb (ranging from 56.18±2.80 to 60.32±4.06 µg/day) and a significant increase at age 13 ($p<0.05$) (Table 1). This may indicate the formation of a rapidly mobilisable and sufficiently stable reserve of glucocorticoids during the long-term adaptation of children to increased physical exertion. It is also known that a constantly replenished reserve of the hormone may act as a buffer, stabilising the levels of free cortisol under various physiological conditions of the body [1].

In the control group, Cb excretion follows the same pattern as Cf; it remains stable between the ages of 11 and 13 (ranging from 32.45±1.34 to 39.84±1.69 µg/day), increases by the age of 14 ($p<0.05$) and reaches its peak at the age of 15 (Table 1).

Dosed physical exercise causes shifts in cortisol excretion, the nature of which depends on the athletes' age. Thus, in 11-, 12- and 13-year-old ice hockey players, an increase in Cf excretion is observed in response to exercise, which is most pronounced at the age of 11 – 118.70 nmol/h ($p<0.05$), at 12 years of age it amounts to 39.04 nmol/h ($p < 0.05$), and at 13 – only 22.80 nmol/h, which is not statistically significant. However, at the ages of 14 and 15, the response takes on a different character, with a significant decrease in Cf excretion observed, amounting to 41.17 nmol/h ($p < 0.05$) (22.69%) and 37.54 nmol/h ($p < 0.05$) (18.71%) at these respective ages. It is likely that with age, as the fitness of young hockey players improves, their bodies' resistance to muscular exertion as a stressor increases (Figure 1).

Table 1. Excreta levels of free (Cf) and bound (Cb) cortisol in boys aged 11–15 years from the sports and control groups (M±m)

Indicators		Age				
		11	12	13	14	15
Cf, nmol/day	SC	219,89±12,42	221,60±14,02	242,80±14,10	206,01±8,31	*173,24±6,05
		•	•	•	•	
	CC	120,62±4,80	132,96±5,92	130,25±5,02	*169,30±7,37	*200,73±7,00
Cb, µg/day	SC	42,92±1,84	38,45±1,75	*54,00±3,00	60,32±4,06	56,18±2,80
		•	•	•	•	
	CC	33,14±1,81	32,45±1,34	39,84±1,69	*46,30±1,90	*60,86±3,82

Note: SC – sports class, CC – control class;

** – differences are statistically significant compared with the previous age group ($p < 0.05$);*

• – differences are statistically significant between SC and CC ($p < 0.05$).

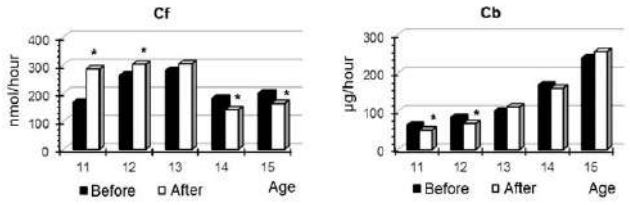

Figure 1 Changes in the excretion of free (Cf) and bound (Cb) cortisol in ice hockey players aged 11–15 in response to a graded exercise test

*Note: Differences are statistically significant compared with rest * – $p < 0.05$*

A different pattern is observed in potassium excretion: unlike free potassium, a graded exercise test causes a statistically significant decrease in potassium excretion in 11- and 12-year-old athletes, amounting to 13.31 μg/h ($p < 0.05$) and 16.25 μg/h ($p < 0.05$), respectively. A decrease in cortisol reserve combined with a sharp increase in Cf may indicate functional stress on the adrenal cortex in young ice hockey players during the adaptation phase to intense muscular activity. With age, Cb excretion stabilises – at 14 and 15 years of age, it is virtually indistinguishable from pre-exercise values – 168.84±10.00 μg/h and 160.45±13.00 μg/h; 240.09±12.00 μg/h and 256.00±18.60 μg/h, whilst at the age of 13 there is a clear tendency towards an increase of 11.29 μg/h (Fig. 1).

Conclusions. Increased physical exertion is the dominant factor in the development of glucocorticoid function in the adrenal cortex of boys aged 11–15. High Cf and Cb levels in young ice hockey players, exceeding those of boys in the control group, indicate the stressful impact of physical exertion, particularly in the early stages of the training process. A decrease in Cf at the age of 15 against a background of stable Cb values, observed both at rest and following a controlled physical workload, may indicate the development of a glucocorticoid reserve during training and an increase in children's resistance to increased physical workload with age.

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