Journal of Sports Physiology and Athletic Conditioning (J.S.P.A.C) 2023; 3 (8):31-43

Research Article

Effects of acute intensive exercise on hormone response in children, adolescents, and youth athletes

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Received: 4 February 2023
Revised: 24 February 2023
Accepted: 8 March 2023

Abstract

Background: The transition from childhood to adulthood is associated with many physiological changes that result from hormonal changes. Despite this, it has been reported that hormonal response to exercise can be age-dependent.the purpose of this study was to investigate growth hormone, insulin, testosterone, and cortisol response to acute intensive exercise in children, adolescents, and youth male athletes.

Materials and Methods: Twenty-nine eligible football players volunteered to participate in the study. Participants assigned to three groups: children (age = 10.88 ± 0.92, n=9), adolescents (age = 14.40 ± 1.17, n=10), and youth (age = 17.70 ± 0.82, n=10). The Bruce Protocol Stress Test was performed as an acute intensive exercise on treadmill. Plasma hormones were measured before and after the exercise.

Results: The acute intensive exercise leads to a significant increase in circulating levels of testosterone (p = 0.02) and Cortisol in children (p = 0.001). In the adolescent group, only a significant increase in GH (p = 0.001) was observed. In the youth group a significant increase in GH (p=0.05) and testosterone (p=0.001) was observed. However, insulin levels did not change significantly after intensive exercise in all groups. Results showed that there were no significant differences between hormonal changes within the three groups.

Conclusion: The results showed that the basal levels of some hormones and their changes after exercise were different. However, the pattern of hormonal changes after acute intensive exercise was similar in children, adolescents, and young athlete boys.

Keywords:
Acute exercise, Hormone response, Different ages, Athletes.

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1. Introduction

The participation of children, adolescents, and youth in exercise programs improved their health and sports performance. However, the physiological response to exercise are not the same at different ages. Accordingly, today one of the areas that have recently been of interest to researchers is the studying of hormonal responses to exercise (1). Some researchers have reported that the hormonal response to exercise differs in childhood and adulthood. In adults, plasma insulin levels decrease during moderate intensity prolonged exercise (75% VO_{2max}) (2). It is well known that puberty is associated with a period of insulin resistance and pubertal adolescents also demonstrate insulin resistance during exercises (3).

Furthermore, in adults, GH levels increase during exercise (4), but the function and physiological effects of this hormone, especially in children and adolescents, are not fully understood. Growing individuals may exhibit different or excessive GH response patterns during exercise (5), (6). Surprisingly, few studies have studied plasma GH response in children and adolescents during intensive exercise. Marin et al. (7) reported that the GH response to exercise significantly increased with increasing puberty stage. Pomerantset al (8) reported the rise of serum GH concentration was highest in the group with Tanner stage III during 30 min aerobic exercise.

Additionally, testosterone and cortisol are known to play a significant role in metabolism and puberty (9). Testosterone increases dramatically in adolescent boys during puberty. With exercise, there is also a small but significant increase in circulating testosterone levels in adolescent boys (10), (11), (12).

The effect of intensive exercise or exercise training on hormonal response, especially testosterone, has been studied mainly in adults and in resistance training. In addition, systematic characterization of the hormone response to exercise in children and adolescents has not been done nearly as wisely as it has been studied in adults. One of the first to measure hormones during exercise in children was Fahey in 1979 (13). No differences in hormonal responses to exercise were found among 27 boys at different stages of puberty, perhaps because only one type of exercise was examined and because only a few hormones were measured (testosterone, GH, and insulin). Since then, only a handful of studies have reported circulating levels of select hormones in children and adolescents, and often the responses are measured only at moderate-intensity exercise.

Sellami et al illustrated (1) total testosterone and cortisol increased with acute exercise (Wingate Anaerobic-Test). Adebero et al (14) greater increase in serum cortisol in men compared with boys (men:242%; boys:64%) and reduced serum Testosterone (men:-14.7%; boys:-33.9%) in response to intensive multitask exercise reported. Among hormones, cortisol is the main catabolic hormone with different responses to various exercises. cortisol catabolic hormone secreted by the adrenal gland, which plays a great role in metabolism. Studies show that cortisol concentration has a linear relation to the exercise intensity (15). Mazdarani et al (16) increases of salivary cortisol concentration in pre pubertal girls of 10- 11 years old after official basketball competition are reported.

The available data on hormone responses to exercise in children and adolescents are sometimes conflicting and limited by the age, gender, and training status of the individuals. In addition, understanding the hormonal response to exercise may help to form better training recommendations for youth of all ages. The purpose of this investigation is to evaluate the effects of acute intensive exercise on hormone response in children, adolescents, and youth soccer players.

2. Materials and Methods

Subjects

Seventy male soccer players of were recruited to participate in this study (Table1). Twenty-nine players with at least 3 years of sports experience, volunteered to participate in the study. Individuals with history of any chronic medical condition or use of any medication were excluded from participation. By football federation classification, participants were divided into three groups of children (n=9, 10–12 years old), adolescents (n=10, 13–16 years old), and youth (n=10, 17–19 years old). The university research council approved the study. Written informed consent was obtained from participants and parents. Subjects were requested to observe normal sleep patterns (with at least 8 hours of sleep), normal daily activity patterns, and dietary patterns before the test, and avoid any physical activity, excessive consumption of food, supplements, medication, coffee, tobacco, and cocoa up to 48 hours before taking a blood sample.

Measurements

Anthropometry. Body height to the nearest 0.1 cm and body weight to the nearest 100 g were determined by standard methods, using a SV-Seca 710 stadiometer and beam scale weight (Seca Precision for Health, Hamburg, Germany). Body mass index (BMI) was calculated as weight/height^2(kg/m^2).

Exercise protocol

Each subject performed the Bruce test on a treadmill as an acute intensive exercise. It was performed until exhaustion. Subjects were vigorously encouraged during the high-intensity phases of the exercise protocol. The Bruce protocol is a standard exercise test that is comprised of seven stages of three minutes each. Stage 1 of the Bruce protocol is performed at 1.7 miles per hour and a 10% gradient. At three-minute intervals the incline of the treadmill increases by 2% and treadmill speed in the first stage to the seventh stage was 2.7, 4, 5.5, 6.8, 8, 8.8 and 9.8 km/h respectively. The subjects performed the test on three separate days. To reduce the effect of circadian rhythm, all blood samples were collected at the same time per day from 7:30 to 9:00 AM.

Blood samples. Blood samples were taken before and after acute intensive exercise then transported to the lab and immediately centrifuged at 3000 rpm, at 4°C for 20 min. GH serum were determined by ELISA with the use of the Biochem Diagnostics kit (Diagnostic System Laboratories. Canada). Intra-assay coefficient of variation (CV) was 3.3–4.5%, inter-assay CV was 5.5–12.9%, and the sensitivity was 0.03 ng/ml. Serum insulin levels were determined by ELISA with the use of the Mercodia kit (Sweden). Intra-assay CV was 1.3–2.6%, inter-assay CV was 5.2–6.2%, and the sensitivity was 0.26IU/ml. Serum cortisol levels were determined by ELISA with the use of the Biochem Diagnostics kit (Diagnostic System Laboratories, Canada). The intra- and inter-assay CV for this assay were 3.2 and 6.8%, respectively. Testosterone serum concentrations were determined by ELISA with the use of the Biochem Diagnostics kit (Diagnostic System Laboratories. Canada). Intra-assay coefficient of variation (CV) was 5.6%, inter-assay CV was 3.2–4.7%, and the sensitivity was 0.04ng/ml.

Statistical Analysis

SPSS software (version 24) was used for data analysis. The changes in variables were analyzed by ANOVA between 3 groups with LSD post hoc test and paired t-tests in each group. Statistical significance was set at P≤0.05. All data are reported as Means±Standard deviation (M±SD).

3. Results

Anthropometric characteristics of participants are presented in table1.

Table 1: Anthropometric characteristics of participants (M±SD)

	Children(n=9)	**Adolescent**(n=10)	**youth**(n=10)
Age(year)	10.88±0.92	14.40±1.17	17.70±0.82
Mass(kg)	27.06±1.27	56.33±3.35	71.00±1.64
Height(cm)	131±3.14	165±2.11	174±4.29
BMI(kg/m^2)	15.69±0.40	20.51± 0.83	23.07±0.24

The results of the paired t-test for comparing pretest and posttest in groups are shown in Table2.

Table 2: paired t–test comparison

	Groups	**Pretest (M±SD)**	**Posttest (M±SD)**	**t**	**sig**
GH(ng/ml)	Children	1.20±0.59	1.42±0.47	-1.25	0.24
	Adolescent	2.36±0.46	2.71±0.57	-6.61	0.001*
	Youth	2.92±0.94	4.03±1.17	-2.20	0.05*
Insulin(ul/ml)	Children	6.95±2.64	6.09±3.36	-0.14	0.89
	Adolescent	5.57±2.53	5.31±2.93	-0.52	0.69
	Youth	8.61±2.80	8.03±4.08	1.22	0.25
Testosterone(ng/ml)	Children	1.99±2.16	2.88±2.36	-2.84	0.02*
	Adolescent	5.68±1.89	6.23±2.37	-1.81	0.1
	Youth	7.81±0.94	8.15±0.83	-3.92	0.001*
Cortisol(mg/dl)	Children	9.27±2.13	10.03±2.41	-1.86	0.001*
	Adolescent	10.92±2.98	12.18±3.30	-1.53	0.15
	Youth	15.96±5.87	15.23±2.54	0.39	0.7

*Within-group changes from pretest-posttest (P<0.05).

GH. At baseline, there was significant difference between groups (F=14.61, P=0.00). Youth GH was significantly higher than children (p=0.00) as well as adolescents GH was significantly higher than children (p=0.00). After intensive exercise, GH levels increased significantly in adolescents (p=0.001) and youth (p=0.05). But no significant changes were noted in children (p=0.24). There was no significant difference between hormonal changes in the three groups (Fig1).

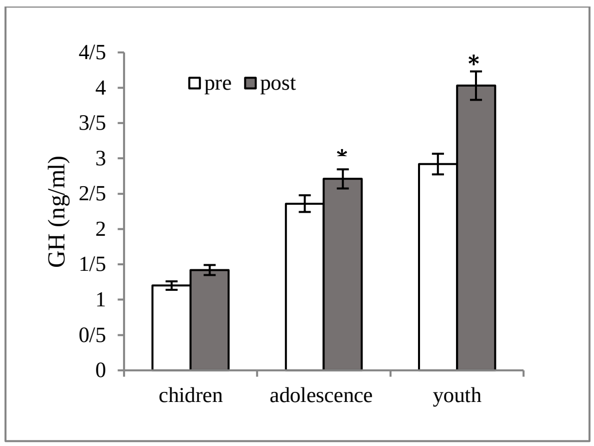

Figure 1: GH changes in groups following the acute intensive exercise

Insulin. At baseline, there was no significant difference between groups (F=3.27, P=0.54). After intensive exercise, insulin levels did not change significantly in any of the groups. (Fig2)

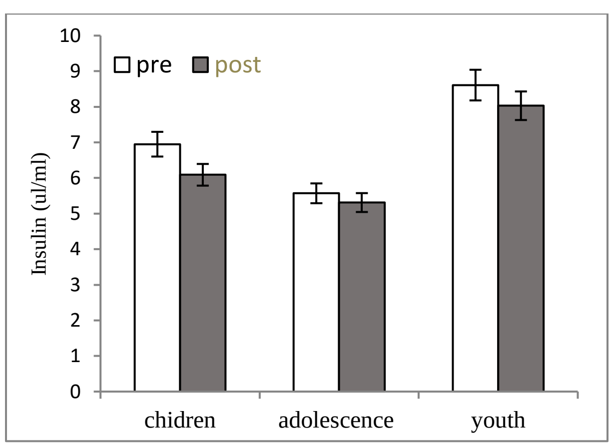

Figure 2: Insulin changes in groups following the acute intensive exercise

Testosterone. At baseline, there were significant differences between groups (F=27.04, P=0.00). Youth testosterone was significantly higher than adolescents (p=0.02) and children (p=0.00). Also, adolescents' testosterone was significantly higher than children's (p=0.00). After intensive exercise testosterone levels increased significantly in children (p=0.02) and youth (p=0.05). But no significant changes were noted in the adolescent (p= 0.1). There was no significant difference between hormonal changes in the three groups. (Fig3)

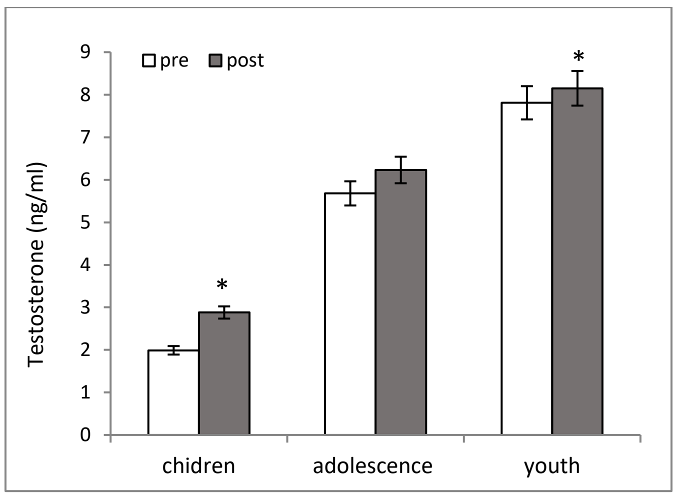

Figure 3: Testosterone changes in groups following the acute intensive exercise

Cortisol. At baseline, there was significant difference between groups (F=7.14, P=0.003).

Youth Cortisol was significantly higher than adolescents (p=0.02) and children (p=0.00). There were no significant difference between adolescents and children (p=0.65). After intensive exercise Cortisol levels increased significantly in Children (p=0.001). There was no significant difference between hormonal changes in three groups. (Fig4)

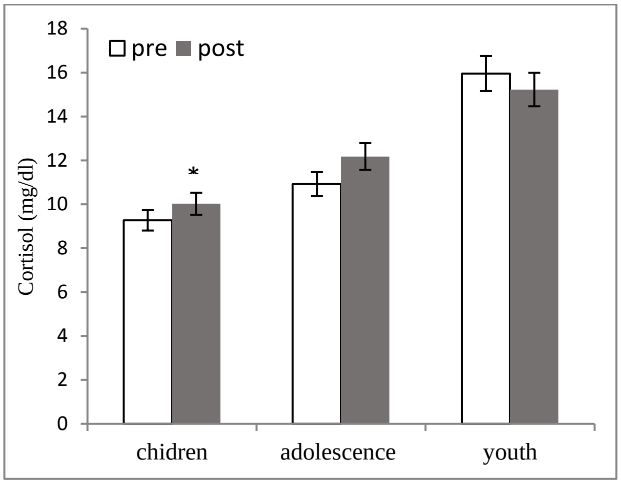

Figure 4: Cortisol changes in groups following the acute intensive exercise

4. Discussion

In the present study, we examined the effects of acute intensive exercise on hormones response in children, adolescent and youth male football players. It is noted that exercise stimulates GH secretion(17). The GH response to exercise depends on the duration and intensity of the exercise, the fitness level of the individual, the timing of blood sampling, and age(18).

GH may play a central role in the regulation of the utilization and storage of energy (9). Previous studies that examined the effects of endurance and anaerobic-type exercise on GH suggested that the exercise should be appropriate to cause a significant metabolic effect (above the lactic anaerobic threshold) to stimulate GH secretion (19). We found that a graded intensive exercise led to a significant increase in GH levels in adolescent and youth.

Socratis et al (20) and Yamaner et al (21) reported that GH concentration significantly increases after intensive exercise in boys. The results of a study showed that GH concentration did not increase after an acute Incremental exercise until 70% maximal oxygen consumption in 10-year-old children (5). In the current study, GH concentrations increased following exercise in all groups, but a significant increase was observed only in adolescent and youth subjects, indicating a more eager exercise-stimulated GH secretion in puberty, approving that exercise-induced GH increase parallels puberty development(22). The combination of rapid growth, high levels of exercise performance, and spontaneous increase in anabolic hormones during puberty suggests the possibility of integrated mechanisms linking exercise to the highest levels of GH secretion in adolescents and young adults. This indicates that an increase in growth hormone is associated with an increase in body mass and athletic capacity during growth (23).

Testosterone is considered the major developer of muscle growth and subsequent increase in muscle strength in response to resistance training(24). In this study, testosterone level increased after intensive exercise, but only in children and youth it was significant. The effects of exercise on hormones were examined in numerous papers and there were some supporting results as well as opposing ones. The majority of studies confirmed an increase in testosterone levels after endurance and resistance exercise. Wegner et al (25) demonstrated acute increases in testosterone concentration immediately after the maximal time trial in adult and adolescent. The increase in testosterone depends largely on the exercise workload and intensity, muscle mass involved, and the athlete fitness level.

In the current study, testosterone levels of the adolescent increased but not significantly. Activation of the hypothalamic-pituitary-gonadal axis causes the progressive secretion of testicular sex hormones, mainly testosterone, during puberty, which are important for biological and behavioral changes. Perhaps these increased testosterone levels due to puberty limit its greater secretion capacity after intensive exercise (21), it seemed reasonable to assume that the alteration in this hormone concentration might affect explosive-type performance as observed in soccer.

Our findings are similar with results from 9 to 10-year-old children, who were exercising with 180–190 bpm for 12 min but they are contradicted from 15-year-old adolescents, who were exercising with 65–75% HRmax for 15 min (25).

In adult, intensive bouts of exercise are known to affect an increase in the circulating concentrations of testosterone and cortisol (25), (26). The training intensity, training duration, adaptation levels of the athletes to training, load/rest ratio, and nutritional differences may affect the results of the studies. Researchers have suggested multiple mechanisms such as stimulation of testosterone secretion by promoting dilatation of vessels and increased blood flow in muscle tissue, increased LH production, and an increase in lactate accumulation following exercise(27). It has also been suggested that there was an increase in sympathetic function due to training, which may lead to a more rapid testosterone response (28).

During exercise, muscle activity increases glucose uptake independently of insulin. (29). Indeed physical activity induces greater insulin sensitivity by increasing glucose transporters in the cell membrane.In adults, plasma insulin levels decrease during prolonged moderate exercise (75%VO_{2max}) (2). In light of decreased insulin sensitivity in prepubertal period and enhanced glucose-induced insulin secretion during puberty (3), specific responses would not be surprising in children and adolescents during physical activity.

Although in this study, decrease insulin after acute exercise was not significant in any of the groups ($p>0.05$). One of the possible reasons is that the subjects are athletes who have less hormonal changes due to the increase of cell membrane receptors. Despite this observation, lack of data makes the characterization of age-related changes in plasma insulin levels after exercise impossible.

Cortisol has been shown to be an indicator of physical and mental stress (28). Despite some inconsistent findings most studies have shown increases in concentrations of cortisol in response to exercise. In the present study, acute intensive exercise did not result in significant change in adolescent and youth groups' cortisol concentration. Only in children did cortisol concentration increase significantly. These data are not in agreement with observations made in 15 to 16-year-old males (12). But Budde et al(30) Showed that Saliva cortisol significantly increases after 12 min high-intensity exercise in 9–10 years old primary school students.

The higher cortisol concentration seen in soccer players was likely an adaptation to exercise induced stress. With regard to our results, it is important to point out that in a single sample analysis the interpretations based on the concentration of hormones in the blood needs to be done with great caution. Soccer has been categorized as high-intensity intermittent exercise and repeated bouts of maximal effort sprints are observed in this sport. It has been previously reported that an increase in physical performances may be related and explained by an increase in plasma testosterone levels coupled with a decrease or maintenance of plasma cortisol levels (31). Probably because of the higher level of physical fitness in adolescent and youth athletics than in children, the intensity of exercise was not sufficient to significantly increase cortisol.

Conclusion

This study investigated the hormone responses to acute intensive exercise in children, adolescents, and youth male athletes. The results showed that the basal levels of some hormones and their changes after the exercise were different. An acute intensive exercise resulted in a significant increase in circulating testosterone in children and youth, whereas the growth hormone was significantly increased after the exercise in the youth and adolescents. and cortisol increased significantly only in children. This hormonal response may affect not only the muscular system, but also other target organs (immune, cardiopulmonary, etc.) Therefore, performing intense exercises by children and its possible effects on other tissues need more research. Although the pattern of hormonal changes was similar in the three groups, it is important to note that the physiologic outcomes of these hormonal changes are also determined by the intensity of exercise as well as age category.

Acknowledgements

We especially thank our volunteers for tolerating what a very unpleasant protocol incurred at times.

Funding

This study did not have any funds.

Compliance with ethical standards

Conflict of interest None declared.

Ethical approval the research was conducted with regard to the ethical principles.

Informed consent Informed consent was obtained from all participants and parents.

Author contributions

Conceptualization: M.F., R.S.; Methodology: M.F., M.A. R.S.; Software: M.F., R.S.; Validation: M.F., R.S.; Formal analysis: M.F., R.S.; Investigation: M.F., R.S.; Resources: M.F., R.S.; Data curation: M.F., R.S.; Writing - original draft: M.A., M.F., R.S.; Writing - review & editing: M.F., R.S.; Visualization: M.F., MA., R.S.; Supervision: M.F., R.S.; Project administration: M.F., R.S.; Funding acquisition: M.F., MA., R.S.

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