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Muscular and cardiovascular effects of sport games and cyclical sports in boys aged 11–14 years

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The aim of this study was to determine the impact of sport games and cyclical sports on the features of cardiovascular reactions to exercising and to the muscular strength in cohorts of boys aged 11–14. The participants of the study were 257 boys aged 11–14: non-athletes, cyclical sport athletes and sport games players. Their muscle strength and cardiovascular indices were registered and taken for analysis.

We have found that training sessions of sport games are an important external factor affecting the functional parameters of accelerated changes in the cardiovascular system (CS) of the 11–13-year age groups. The influence of endogenous factors on a child's growth and development notably increases at the age of 13–14 years, resulting in a significant improvement of CS indices, and non-athlete children by these following characteristics almost equal their peers engaged in sports. The improvement of muscular capacity indices depends on the nature of physical load: muscle strength indices increased more significantly in the cyclical sports group.

Key words: cardiovascular system, muscles, sport games, cyclical sports

INTRODUCTION

Maturation processes determine the interaction of inherent (endogenous) and acquired (exogenous) factors [1]. A significant role in this interaction belongs to the exogenous factors such as physical activity, the nature of physical load and its other characteristics [2]. The activity of the CS is exceptionally important in the chain of adaptive mechanisms [3, 4]. Epidemiological studies of other scientists highlight the positive effects of physical exercise on the working capacity and functional state of the muscles and cardiovascular system [5–7]. However, the specificity of the exercise selection is relevant: which of the two – sports games (partially regulated physical load) or cyclical sports (strictly regulated physical load) – has a greater impact on the development of muscles and CS features? Children choose a specific sport, and for a long time regularly attended training sessions become a significant factor in the prevalence of the nature of physical exercises [8]. This paper examines the long-term training effects of different sports on boys' muscles and CS.

In the long run, multiple physical load changes heart and vascular system adaptation [9]. Regular physical load leads to an increase of CS functional capacity. Cardiac functional capacity is often the body's adaptive potential restricting factor; therefore, cardiac adaptation to maximal physical load is one of the key conditions that determine the overall adaptation of the organism to its environment. While the growth of organism during the first 10–15 years, of the main importance in increasing heart employability during exercise is heart rate (HR). CS changes cause activation of different physiological adaptation patterns by the physical load in different age stages [3, 10].

The aim of this study was to determine the impact of sport games and cyclical sports on the features of cardiovascular reactions to exercising and to muscular strength in cohorts of boys at age 11–14.

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MATERIALS AND METHODS

Subjects

The study involved 257 boys aged 11–14 years – Lithuanian high school and sports school pupils (healthy, no bad habits). All subjects were divided into three groups: non-athletes (n = 85), cyclical sports athletes – runners (n = 89) and representatives of sports games – basketball, handball, football (n = 83) (Table). The boys had been going in for the chosen sport for no less than 2 years.

Methods

The study was carried out at Kinesiology Laboratory, Lithuanian Academy of Physical Education, in spring 2006 (April / May), at the same time of the day. Two days before testing the boys had not performed all-out exercise.

The local ethical committee approved the study protocol. The subjects underwent dosed exercise tests, i. e. the Rouffier test (30 squats per 45 seconds) and all-out exercise tests, i. e. a 30-second vertical jump test (JT) [11]. The computerized ECG analysis system "Kaunas-load", developed at the Kaunas Medical University Institute of Cardiology, was employed for 12 synchronous ECG recordings and analysis. During the testing procedure, 25 intervals of ECG were registered. Changes in heart rate (HR) and JT interval as a sum in 12 leads were analyzed. Because the JT interval is an indicator of the duration of ventricular repolarization [12], and its change is closely related to the myocardial metabolic changes [13], it is an important cardiovascular index.

Muscle strength was measured with the Nicholas hand dynamometer. With this device, the maximum force required for the isometric muscle contraction mode is obtained when the resistance caused by the research investigator appears. The interval of the dynamometer is between 0 and 199.9 kg, therefore it is possible to evaluate the strength of the major muscles. The device is placed between the investigator's arm and the investigative arm. The investigator's pressure force through the dynamometer is aimed at the investigative upper limb. We measured the strength of arm levators and femoral flexors, calf extensors and flexors and forearm extensors and flexors.

Statistical analysis

In order to compare the data, we determined the arithmetical mean ($\bar{X}$) and the standard deviation (SD). To evaluate significant differences of values, we used one-way analysis of variance ANOVA (Student's test sum of several independent samples). The following statistical significance levels were used: $p < 0.05$ – reliable, $p < 0.01$ – highly reliable, $p < 0.001$ – particularly credible conclusion.

RESULTS

To compare the results of dynamometry in four age groups (11, 12, 13, and 14 years), we measured selected groups of muscles on the right and left side (arm levators (Fig. 1), femoral flexors (Fig. 2), calf extensors (Fig. 3) and flexors (Fig. 4) and also forearm extensors and flexors), and found that the best results were achieved by cyclical sports athletes. The lowest results were obtained in non-athletes. The arm levator strength data show that in all age groups there was a statistically significant difference between non-athletes and cyclical sports athletes, i. e. cyclical sports athletes showed higher values of arm levator strength as compared with the non-athlete group. Similarly, considering the age aspect, these parameters were lowest in boys aged 11 years. Measurements of femoral flexor strength also revealed higher results in the cyclical sports group, no statistically significant differences were found only for the age group of 12 years. The calf extensor strength among 11–13-year-old

Table. **Characteristics of subjects**

Subjects age	Sport event	Stature, cm	Body mass, kg
11 years	Non-athletes (n = 22)	153.3 ± 2.2	45.6 ± 3.4
	Cyclical sport athletes (n = 22)	147.5 ± 1.3	36.3 ± 2.0
	Sport games players (n = 21)	152.4 ± 1.3	42.4 ± 2.0
	Mean value	151.0 ± 8.1	41.4 ± 12.4
12 years	Non-athletes (n = 18)	158.6 ± 1.8	46.6 ± 1.8
	Cyclical sport athletes (n = 20)	159.1 ± 2.3	46.6 ± 2.5
	Sport games players (n = 20)	157.6 ± 2.5	46.6 ± 2.7
	Mean value	158.4 ± 9.8	46.6 ± 10.4
13 years	Non-athletes (n = 25)	165.7 ± 2.4	52.5 ± 2.1
	Cyclical sport athletes (n = 24)	165.2 ± 1.7	50.1 ± 2.0
	Sport games players (n = 22)	168.7 ± 1.8	54.2 ± 1.7
	Mean value	166.5 ± 9.7	52.2 ± 9.6
14 years	Non-athletes (n = 20)	173.9 ± 1.6	63.5 ± 2.3
	Cyclical sport athletes (n = 23)	172.0 ± 1.8	55.5 ± 1.8
	Sport games players (n = 20)	172.6 ± 1.7	57.7 ± 2.1
	Mean value	172.8 ± 7.8	58.7 ± 9.9

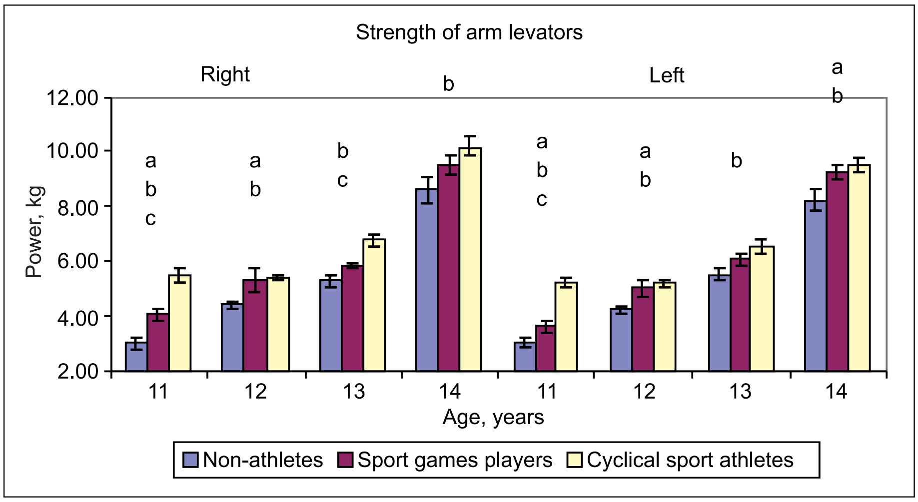

Fig. 1. Arm levators strength in non-athletes, sport games players and cyclical sport athletes. Note. The difference between non-athletes and sport games players – a, cyclical sport athletes and non-athletes – b, sport games players and cyclical sport athletes – c – statistically significant at $p < 0.05$

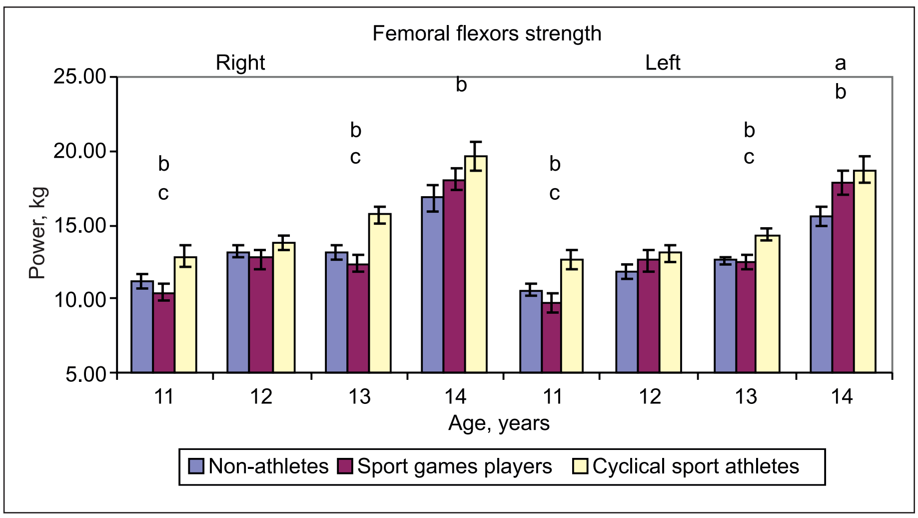

Fig. 2. Femoral flexors strength in non-athletes, sport games players and cyclical sport athletes. Note. The difference between non-athletes and sport games players – a, cyclical sport athletes and non-athletes – b, sport games players and cyclical sport athletes – c – statistically significant when $p < 0.05$

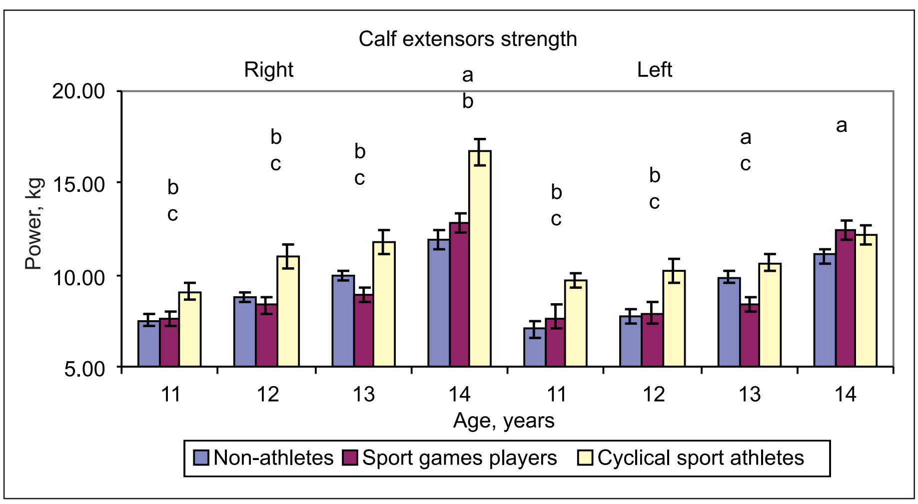

Fig. 3. Calf extensors strength in non-athletes, sport games players and cyclical sport athletes. Note. The difference between non-athletes and sport games players – a, cyclical sport athletes and non-athletes – b, sport games players and cyclical sport athletes – c – statistically significant when $p < 0.05$

boys was highest in cyclical sports athletes and the calf flexors strength in boys aged 11 and 12 years.

Measurements of forearm flexor strength showed the best results in cyclical sports groups, and there was a statistically significant difference as compared with the results of non-athletes and sport games players. The same situation was observed in the evaluation of forearm extensors' strength on the right and left sides of boys-aged11 and 13 years.

Dynamometry assessments showed that the muscle strength of the cyclical sport athletes was greater than of non-athletes and sport games players. Statistically significant differences were identified in all age groups in the assessment of both right and left sides.

The HR dynamics of non-athletes, sport games players and cyclical sport athletes aged 11–14 years, after Rouffier and 30-s vertical jumping tests is presented in Fig. 5. In the groups of 11, 12 and 14 years, no statistically significant differences between athletes and non-athletes were found, i. e. cardiovascular system processes changed depending on the protocol of testing to a similar extent in all three groups. Also, in 13-year-old non-athletes and cyclic sports athletes HR results were similar. However, data of these both groups throughout the study exhibited a statistically significant difference as compared to the sport games players. Therefore, these results suggest a faster mobilization and recovery processes in the cardiovascular system of the sport games players.

Evaluation of metabolic changes in the myocardium was based on the analysis of the JT interval dynamics of

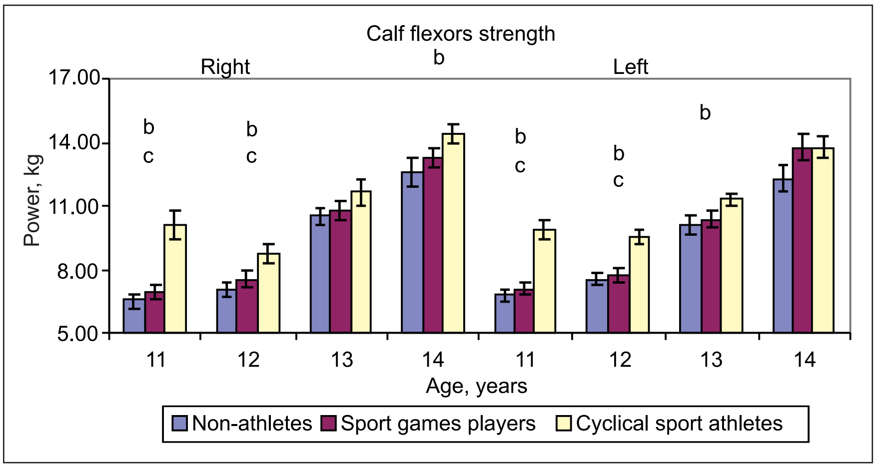

Fig. 4. Calf flexor strength in non-athletes, sport games players and cyclical sport athletes. Note. The difference between non-athletes and sport games players – a, cyclical sport athletes and non-athletes – b, sport games players and cyclical sport athletes – c – is statistically significant when $p < 0.05$

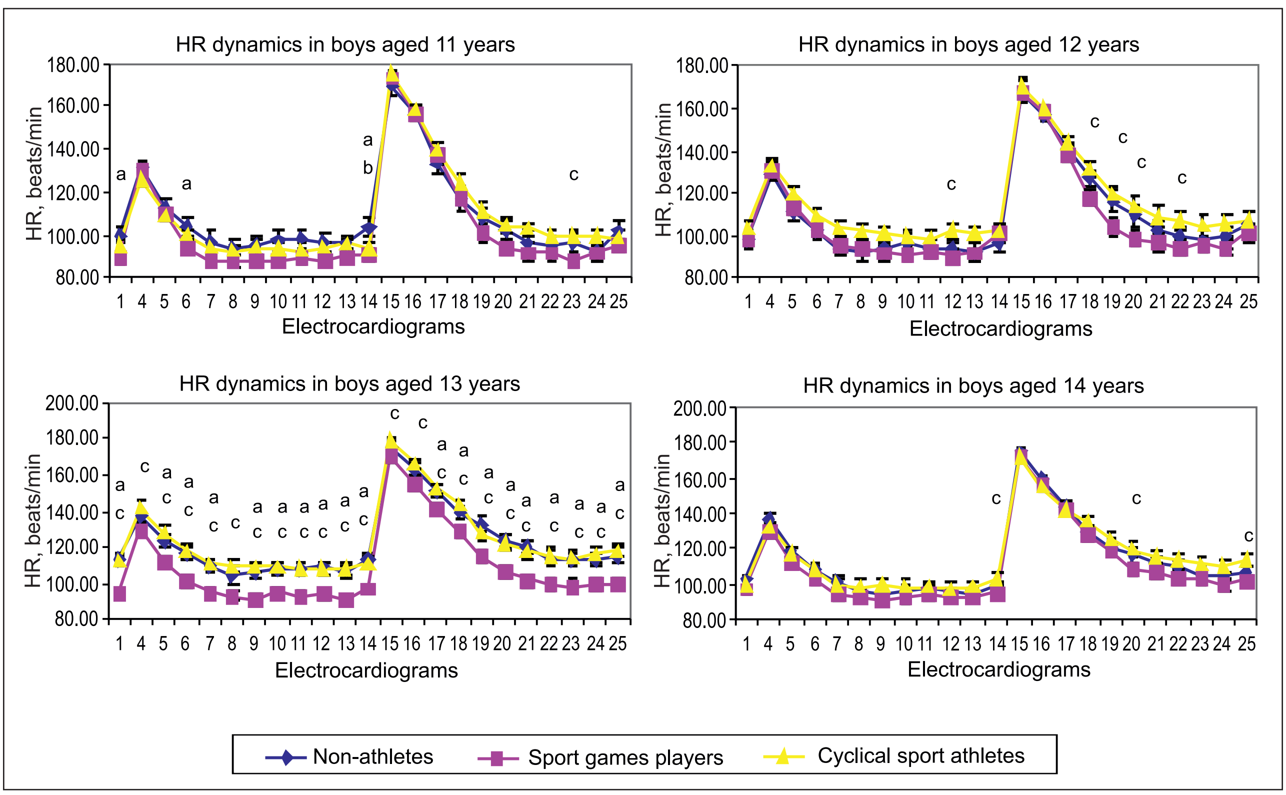

Fig. 5. HR dynamics of 11 to 14-year-old non-athletes, sport games players and cyclical sport athletes during Rouffier test and 30 s vertical jumping test. Note. The difference between non-athletes and sport games players – a, cyclical sport athletes and non-athletes – b, sport games players and cyclical sport athletes – c – statistically significant at $p < 0.05$. 1 ECG – before load; 4 to 14 ECG – recovery after Rouffier test; 15–25 ECG-recovery after 30 s vertical jumping test

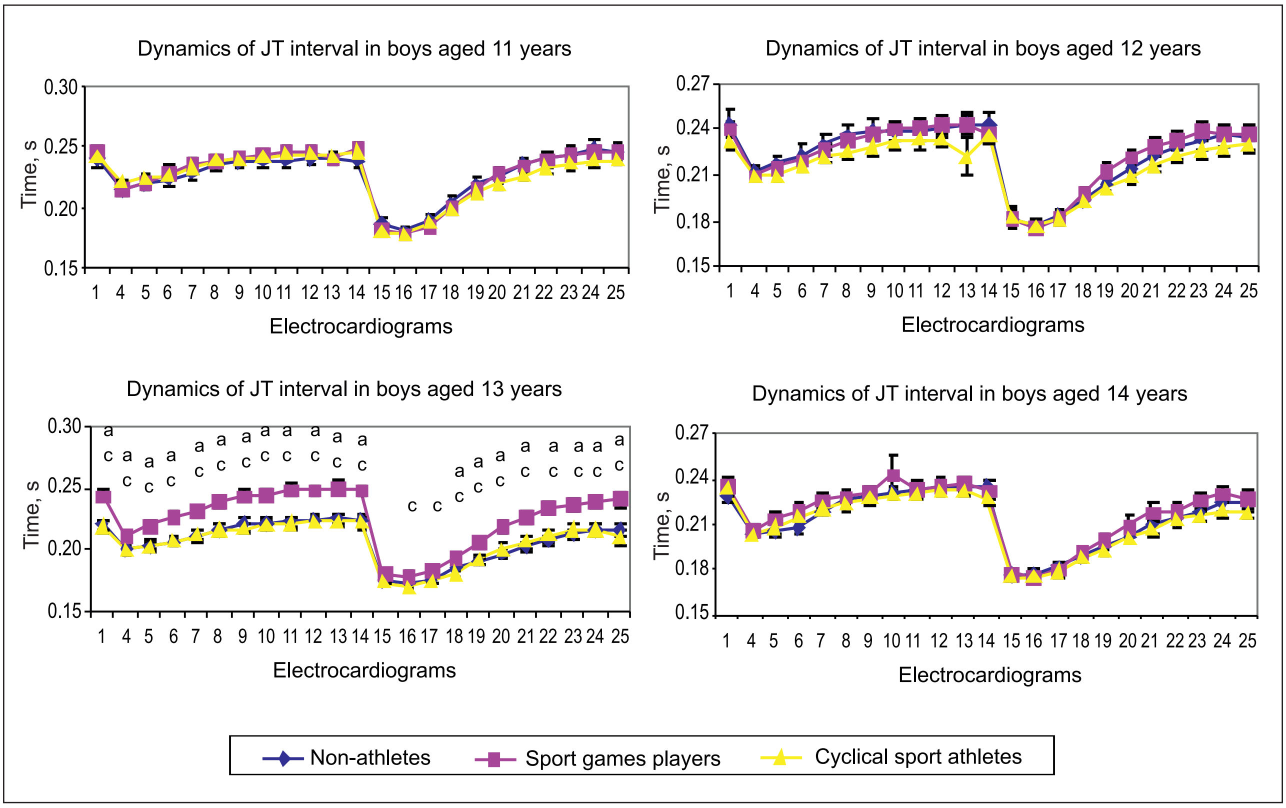

Fig. 6. JT interval dynamics of 11 to 14-year-old non-athletes, sport games players and cyclical sport athletes during Rouffier test and 30 s vertical jumping test. Note. The difference between non-athletes and sport games players – a, cyclical sport athletes and non-athletes – b, sport games players and cyclical sport athletes – c – statistically significant when $p < 0.05$. 1 ECG – before load; 4 to 14 ECG – recovery after Rouffier test; 15–25 ECG-recovery after 30 s vertical jumping test

non-athletes, sport games players and cyclical sport athletes aged 11–14 years before the load, after the Rouffier and after 30-s vertical jumping tests. The results are presented in Fig. 6. No statistically significant difference was found between athletes and non-athletes in the 11, 12 and 14 years age groups. A completely different situation was observed in the 13-year-old boys. Here, the largest extent of the JT interval alteration was found in sport games players as almost in all stages of the investigation the differences were statistically significant compared to non-athletes and cyclical sports representatives.

DISCUSSION

The body's reaction to physical exercises, which belong to the group of external factors affecting the body growth and development, has an impact on the functional and morphological changes in bodily systems [14, 15]. The period most sensitive to external influences is 11–14 years. Investigations of boys of this age, engaged in sports, may reveal a complex interaction of the inherent and acquired (endogenous and exogenous) factors.

In this work, we studied the impact of sport games and cyclical sports on the dynamics of the functional state of the body in boys aged 11–14 years. We have found that the nature of physical load (partially regulated, specific of sport games, and a strictly regulated physical load specific of cyclical sports training sessions) differently affects the features of CS in the growing and rapidly evolving body.

A comparison of the obtained data revealed the lowest HR values in the 13-year sport games players, which significantly differed from the values found in non-athletes and cyclical sports athletes. Lower HR values show that boys attending sport game trainings exhibit a longer diastole (heart relaxation) and a faster mobilization of CS at the onset of exercise. This confirms the opinion of other authors [16, 17] that specific exercises used in the sport games training sessions, partially regulating the nature of physical load, have an effect on adaptation dynamics.

The results obtained during the study showed that in all boys aged 11, 12 and 14 years the dynamics of JT interval was similar, and no statistically significant difference among the groups was found. But at the age of 13 years, the JT interval values after dosed exercise tests in sport games players significantly differed from those of cyclical sports athletes and non-athletes. Other researchers [18, 19] also maintain that the endogenous factors, especially at the age of 13–14 years, have a great influence on the CS, so that even in non-athlete children the functional indices of the CS improve rapidly.

Although the results of the CS dynamics were better in representatives of sports games, dynamometry assessments showed that muscle strength was higher in cyclical sports athletes, but not in non-athletes or players. Statistically significant differences were identified in all age groups while assessing the right and left sides. Muscle capacity data have confirmed the opinion of other authors that exercise affects the growth and development processes [20, 21].

A lot of research work has been done to assess the patterns of the growth and development [22, 23] and to find the most appropriate physical load [24–27]. Data of other researchers and the results of our study suggest that the interaction of the external and internal factors determines the development peculiarities of muscles and the functional capacity of the CS and their expression during exercise in boys aged 11–14 years. Physical load of variable intensity, specific of sport games training sessions, is a significant external factor accelerating the changes of cardiovascular functional parameters at the age of 13 years. However, the endogenous factors, especially in 13–14-year age groups, are strongly influenced by the CS, so that even in non-athlete boys the CS functional parameters improve rapidly, and according to these indices non-athlete children almost equal their peers engaged in sports. Precisely regulated physical load specific of cyclical sports is an external factor affecting the boys' muscle strength parameters at the age of 11–14 years.

These results can be explained by findings of other authors [8], where differently targeted physical loads, creating different relations of external and internal stimuli lead to different features of adaptation. Thus, because of the regular physical loads, in sport games players it is the functional state of the CS and in cyclical sports representatives the muscular system performance that improve faster.

To sum up these results, it is necessary to take into account the fact that the athletes' physical maturity and functional preparedness indicators are the outcome of selection and adaptation dynamics [10, 28–30]. It is well known that the initial functional preparedness of a child is an important factor in choosing the kind of sports activities and in sport selection as well. Nevertheless, our study confirms the findings of other researchers [6, 17, 30–32] that sports activities unquestionably have an impact on the capacity of the cardiovascular system and skeletal muscles.

CONCLUSIONS

1. Sport games training sessions are a significant exogenous factor affecting the functional parameters of accelerated changes in the cardiovascular system of boys aged 11–13 years. The influence of endogenous factors on a child's growth and development significantly increases at the age of 13–14 years due to changes of important cardiovascular indices, and non-athlete children become almost equal to their athlete contemporaries as regards these parameters.

2. The improvement of muscle capacity indices depends on the nature of physical load: muscle strength indices increased more significantly in the cyclical sports group.

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SPORTINIŲ ŽAIDIMŲ BEI CIKLINIŲ SPORTO ŠAKŲ POVEIKIS 11–14 METŲ BERNIUKŲ RAUMENŲ IR ŠIRDIES KRAUJAGYSLIŲ SISTEMAI

Santrauka

Šio darbo tikslas – nustatyti sportinių žaidimų bei ciklinių sporto šakų poveikį raumenų ir širdies kraujagyslių sistemos (ŠKS) funkcinių rodiklių kaitos ypatybėms 11–14 metų amžiaus tarpsniu. Tyrimo kontingentą sudarė 257 berniukai 11–14 metų amžiaus: nesportuojantys, sportuojantys ciklinėse sporto šakose ir sportinių žaidimų atstovai. Darbe buvo vertinami raumenų jėgos ir širdies kraujagyslių sistemos rodikliai.

Nustatėme, kad sportinių žaidimų treniruotės yra reikšmingas išorės veiksnys, turintis įtakos greitesnei ŠKS funkcinių rodiklių kaitai 11–13 metų amžiaus tarpsniu. Lemiamas endogeninių veiksnių poveikis vaiko augimui ir vystymuisi ypač sustiprėja 13–14 metais, dėl to pagreitėja reikšmingų ŠKS rodiklių pokyčiai ir nesportuojantys vaikai pagal šiuos rodiklius beveik prilygsta sportuojantiems bendraamžiams. Raumenų darbingumo rodiklių gerėjimas priklauso nuo krūvio: ciklinių sporto šakų grupėse besitreniruojančių berniukų raumenų jėgos rodikliai buvo didesni.

Raktažodžiai: širdies kraujagyslių sistema, raumenys, sportiniai žaidimai, ciklinės sporto šakos