ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Left Ventricular Ejection Time in Children and Adolescents.

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ABSTRACT

The study of the left ventricular ejection time in children and adolescents revealed its increase with age.The total ejection time significantly decreases under functional load in the cohort under study, aged 10-15 years. The gender differences become statistically significant only at 14-15 years of age, and the rapid blood ejection time is a constant value of the period of blood ejection. On active change of the body position, significant differences in the ratio of rapid and slow ejection time to the total time of the blood ejection into the systole are observed in girls and boys being in the upright body position. The systolic ejection has a statistically significant decrease independent of the gender differences, at the same time differences are determined in case of the functional load. The obtained results indicate that in the age range of 10-15 years a significant decrease of the heart rate andthe maximum duration of the left ventricular ejection time are revealed in adolescents aged 14-15years.

Keywords: heart, blood ejection time, children and adolescents, active change of the body position

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ISSN: 0975-8585

INTRODUCTION

In the process of ontogenesis, the formation of chronotropic and inotropic cardiac functions takes place heterochronically. High sensitivity of the human body to changing environmental factors is manifested in the period of accelerated development of the circulatory system [6]. Application of methodological foundations for the assessment of the regional population health risk in the city of Kazan associated with the effect of unfavorable environmental factors allowed revealing high risk of endocrine diseases, digestive diseases, neoplasms, circulatory diseases and others among adolescents. These findings defined the interest in the studies of the age group of 10-15 years and the priority of changes in the circulatory system.

The time of the blood ejection from the heart is an important indicator of the functional status of the myocardium, it is closely connected with the cardiac rhythm, decreasing with its acceleration and increasing with its deceleration. During the blood ejection, the heart performs mechanic work on the systolic blood volume shift. The greatest volume of the heart useful work is performed during the rapid ejection phase, the major part of the systolic blood volume is ejected, the hemodynamic efficiency of the reduced ejection phase being relatively low. The blood ejection time reflects the total time of the blood ejection into the systole. There is also relationship between the duration of the ejection period and the stroke volume output: the higher the stroke volume is, the longer its ejection is [3, 4]. With age, the left ventricular ejection time increases. The indicators of the cardiac rhythm are in close relationship with gender, age and degree of adaptation to conditions of the endogenic and exogenic environmental factors.

The impact of different load types, individual peculiarities have a considerable influence on the degree of the heterochronism manifestation of the pumping function of the heart in children and adolescents [1, 2]. Compensatory reactions of the cardiovascular system focused on coping with the force of gravity and maintaining optimum blood supply to the bodytake placeunder functional load in the form of an active change of the body position.

Shifts of the cardiac cycle phase characteristics are observed upon change of the body position: the phase of isometric contraction elongates, the left ventricular ejection time, mechanical and total systoles shorten [5, 8].
The aim of the research is to study the influence of the functional load on the duration of rapid and slow left ventricular ejection in children and adolescents aged 10-15 years.

MATERIALS AND METHODS

186 pupils aged 10-15 years living in the city of Kazan took part in the study. The study groups were formed according to the “copy-pair” principle. The control and experimental groups were formed with the account of gender and age differences, the experimental group performing the functional load (active change of the body position). We used a double-channel four-electrode impedance plethysmograph "Reodin-500" with an attachment for computer analysis DRT-01 (digital-output rheographic transducer). Analysis of the amplitude-time characteristics of the differentiated rheogram was carried out. Quantitative indicators of the ventricular ejection time were studied. The left ventricular ejection time (tu), rapid (a) and slow blood ejection(b) were determined both in absolute units (sec), and in relative values (%). The values were calculated according to the formula, a% = (a x 100/ tu) and b % = (b x 100/ tu). Changes of such indicators of the pumping function of the heart as the heart rate (HR), stroke volume (SV) and minute volume (MV) both at rest, and under functional load were determined. The validity of the analyzed indicators was checked with Student’s T-test.

RESULTS

A differentiated rheogram allows obtaining data on the vascular tone andthe myocardial contractility. We determined the decrease of amplitude characteristics of the differentiated rheogram (DR) with age in children and adolescents aged 10-15 years in both groups under study.

According to the obtained findings, the ejection time (tu) in girls aged 10-11 years in prone position made 0,220±0, 0026 sec, and it didn’t differ considerably from the values found in boys (Fig.1). Transition to the sitting position determined the decrease of the ejection time in girls, which made 0,213±0,0012sec ($p<0.05$).

ISSN: 0975-8585

Active transition to the upright position caused the change of the ejection time up to 0,193c ($p<0.001$) in girls and up to 0,197 sec ($p<0.001$) in boys.

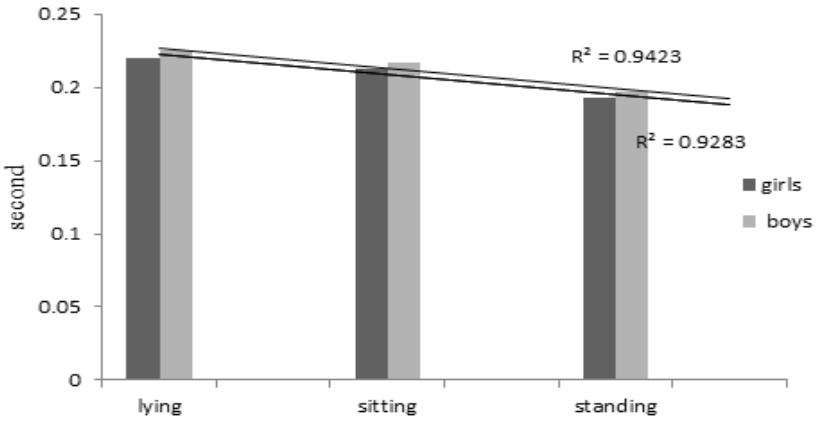

Figure 1: Left ventricular ejection time in children aged 10-11 years

The increase of the left ventricular ejection time and the decrease of the maximum velocity of the blood ejection are known to occur with age [7]. In boys, aged from 10 to 15 years, from the groups under study, the ejection time in prone position changed significantly in the experimental group (from 0,225secto 0,247sec) ($p<0,001$). The growth of this value in sitting position is less pronounced with age and is statistically significant only in boys.

The period of blood ejection consists of the rapid and slow ejection time. The ratio of the rheogram amplitude to the ventricular rapid ejection time allows estimating the myocardial contractility. In boys, in prone position, the duration of the rapid (a) and slow (b) ejection time of the differentiated rheogram increases with age, considerable changes occurring at the age of 14- 15 years.

According to the results obtained, the indicators of the rapid blood ejection relative values (a%) increase on the sequential body position change independent of the research subject's gender: from 24, 40% to 26,85% in girls, and from 24,35% to 26,05 % ($p<0,001$) in boys. The gender differences become statistically significant only in the upright position, thus in girls, the indicator (a%) is considerably higher, and (b%) is lower ($p<0,05$).

At the age of 12-13 years, the blood ejection time in the experimental group decreases considerably on performing the functional load ($p<0,001$), resulting in the change of the rapid and slow ejection time ratio (Fig.2).

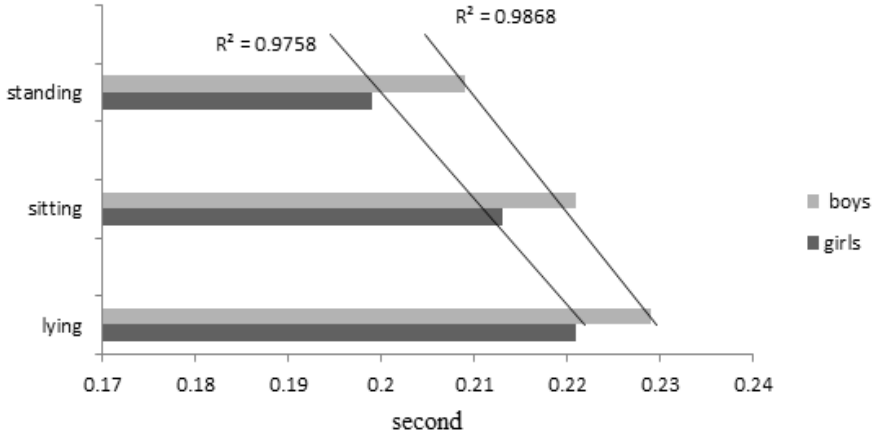

Figure 2: Left ventricular ejection time in children aged 12-13 years

ISSN: 0975-8585

In girls aged 14-15 years, the ejection time in the initial position of the body makes 0,230±0,005sec, which is far less than in boys (p<0,01). It is worth noting that on change of the body position at the age of 14-15 years the time of blood ejection depends on the gender of the research subjects, and the total ejection time is longerin the group of boys (p<0,01) (Fig.3).

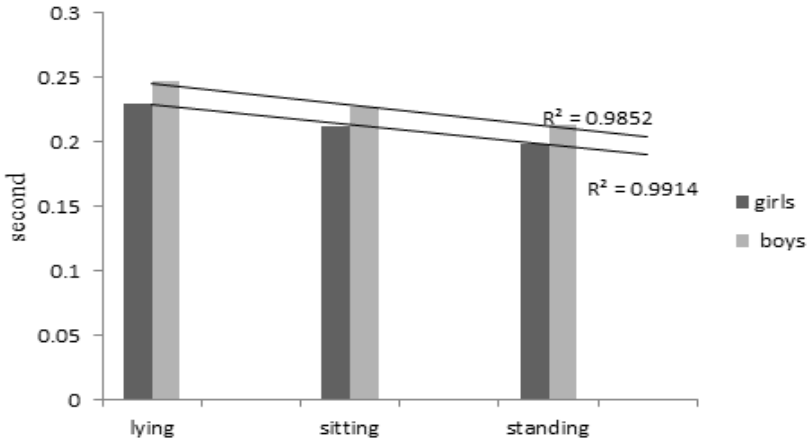

Figure 3: Left ventricular ejection time in adolescents aged 14-15 years

The analysis of indicators of the rapid blood ejection (a%) relative values in the initial position at the age of 14-15 years revealed no significant differences between the groups. On active transition to the upright position, the significant increase is determined in the experimental groups: upto 26, 19% (p<0, 01) in girls, and up to 25, 70% in boys (p<0, 01). It should be noted that under load the indicator (a%) is independent of gender differences at this age.

We revealed the absence of marked changes of the indicator (a%), which remained constant value in all body positions with age in both groups under study. It proves that rapid blood ejection is a constant value of the total ejection time in children of both genders at the age of 10-14-15 years. There is a tendency for the increase of the relative values of slow blood ejection (b%) with age, under functional load this value decreases significantly the upright position of the body.

LV filling pressure is connected with the amplitude of the systolic and diastolic waves, and the left ventricular minute work. The given value in the groups aged 10-11- and 12-13 years doesn't change significantly. The difference in the LV filling pressure is marked at the age of 14-15 years, this indicator being lower in boys and making 17,09±0,33 mmHg. (p<0,05).

Summing up the changes of the heart rate (HR) andthe stroke volume (SV) indicators, on active change of the body position in the groups under study aged 10-11 years, we can say that changes are diametrically opposite. While performing the given functional load, HR increases, whereas SV decreases. The analysis of the indicators of the pumping function of the heart showed that greater decrease of the SV occurred on active transition from the prone position to the sitting position in the group of girls, where as in boys– on transition from the sitting position to the upright position.

We revealed that considerable changes of Heart rate, Shock volume of blood, Minute blood volume 10-11 and 14-15 years old occurred on active transition from the prone position to the sitting position, in boys– to the upright position.The sympathetic division of the autonomic nervous system maintaining the hemodynamical stability is activated on transition to the upright position. The increase of the chronotropic reaction occurs against the background of the stroke volume decrease, it being one of the main compensatory mechanisms in the cardiac activity, and all this helps to maintain the minute blood volume.

CONCLUSION

Thus, the blood ejection time, which reflects the total time of ejection into the systole, is significantly longer in the group of boys aged 14-15 years. When analyzing the amplitude-time characteristics of the

differentiated rheogram (DR), which reflect the state of the vascular tone, we revealed the heterochronism of the amplitude indicators of systolic and diastolic waves. The decrease of the given values under functional load is due to the age, and gender differences are identified only at the age of 14-15 years. In girls of the experimental and control groups,the DR amplitudes are higher at rest, and on active change of the body position their decrease begins earlier. This fact can indicate that the girls have hyperreactivity of the pumping function of the heart, and the indicators respond significantly in the first minutes of the change in the body position, which is confirmed by the significant decrease of the stroke volume. In boys, the given response is determined only on transition to the upright position, that is, periodically.

Consequently, the revealed heterochronic changes in indicators of the pumping function of the heart, at the age of 12-13 years in particular, can be explained by puberty in girls, in boys of the experimental group - the significant changes are manifested at the age of 14-15 years. Performance of the functional load with age does not cause such a pronounced reaction of heart rate, as systolic ejection of blood.

ACKNOWLEDGEMENTS

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

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