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The Impact of Puberty Physical Development and Heart Rhythm Variables

by

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The objective of the present article is to investigate the impact of puberty on the level of physical development and autonomous control of heart rhythm.

The results indicate that both, body height and body mass were lowest in the first puberty stage group of girls. The differences in body height in all the groups investigated were statistically insignificant. A comparison of body mass values indicates that girls belonging to the first group (first puberty stage), have significantly lower values of this variable ($p<0.05$) than those belonging to the second and third puberty stage groups. Those belonging to the third puberty stage group have the highest body mass.

A general overview of heart rhythm frequency (RR) and general rhythmic dispersion (SRR) parameter analysis results shows that the lowest rhythm and the highest rhythmic dispersion is typical of the first puberty stage girls (group 1) whose puberty started later. Meanwhile, the highest and most stable rhythm of the heart is typical of the girls belonging to the highest puberty stage (group 3). The results indicate that faster physical development related to early beginning of puberty leaves behind the development of the basic biological systems. This research shows that more frequent and more stable heart rhythm typical of girls whose puberty starts earlier (group 3) is an indirect manifestation of lower functional capacity of their circulatory systems in comparison with those belonging to groups of slower and later puberty.

Key words: *puberty, biological development, heart rhythm, physical development.*

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Introduction

The development of physical abilities and functional capacities has great importance on adolescents' sports performance. Determining the manifestation of their dynamics allows to estimate biologically sensitive periods in adolescent lives and to optimize the impact of physical education health and sport results (Docherty et al. 1996; Drozdowski 1997). In the process of child and adolescent physical education and sports activities, particular attention should be paid to controlling and estimating physical status of schoolchildren who do and do not participate in sports, as this later determines their sports orientation and their sport achievements (Vilkas 2004).

Development of functional systems of an adolescent's body is related to the process of growth and biological development; it continues until full maturity is achieved (Katinas and Vilkas 2002). A growing and maturing body undergoes quantitative and qualitative morphological and motor changes (Gailiuniene and Kontvainis 1994; Gabbard 1996; Straub et al. 1997; Kepeženas and Vilkas 2003). An analysis of literature indicates the significance of the child, adolescent and youth education, especially during the puberty period, when hormone and psychophysical status of the body is being formed. The puberty process impacts individual development and manifests its own peculiarities (Docherty 1996; Bouchard et al. 1997; Osinski 2000). Qualitative and Quantitative changes of bodily functions taking place in the developmental stage are related to the peculiarities of autonomic heart rhythm control during puberty (Žemaityte 1997).

Research papers devoted to heart rhythm variability in the aspects of sex, physical fitness adaptation to physical loads indicate that estimation of autonomic heart rhythm control according to heart rhythm variability allows a quite objective judgment of the functional status of the cardiovascular system and its possibilities to adapt to physical loads (Žemaityte 1997; Kepeženas and Žemaityte 1998; Aubert et al. 2001; Lee et al. 2003; Musialik-Lydka et al. 2003; Perini and Veichsteinas 2003; Acharya et al. 2004). Nevertheless, the authors have not found any data in literary sources on the relationship between the level of autonomic heart rhythm control and physical capacity, depending on adolescent's biological development level. The aforementioned factors are important in optimization of physical loads during sports training during puberty. It is assumed that estimation of cardiovascular system functional status according to the level of autonomic heart rhythm control and determining adolescent puberty phases will be helpful in optimizing the training process and in avoiding possible overtraining.

The aim of the present work is to analyze and to estimate puberty level of 13 – 14 year old girls as well as its impact on physical development and autonomic control of heart rhythm.

Material and methods

The research material included 40 adolescent girls aged 13 – 14 and selected according to puberty phases. The research was carried out at Geroji Viltis Secondary School in Vilnius City.

The girl's puberty phases were determined using the method of estimating the level of development of secondary sexual characteristics (Vlastovskij 1976). Two variables of physical development were recorded (body height-cm and body mass-kg. On the basis of puberty, three groups of participants were distinguished and formed. The first group consisted of girls whose puberty started late and who were in the first puberty phase (n=13), the second group included girls having normal puberty and belonged to the second phase (n=12), and group three consisted of third-phase (early puberty) girls (n=15).

To estimate heart rhythm characteristics, the rhythmography method was used which allowed for the determination of rhythm frequency (RF), rhythm dispersion (RD) and absolute values of very low frequency (VLFC), low frequency (LFC) and high frequency components (HFC) in the heart rhythm spectra as well as percentile values (NVLFC, NLFC, NHFC) of the same components in the lying position at rest. While performing active orthostatic sampling, we determined maximal increase of heart rhythm while standing-up (RF_B) and the amplitude value (? RF_B). Heart rhythm reaction to a standard load was estimated using the Roufier test and expressed in relative measurement units.

Results and discussion

Heart rhythm variability while at rest and heart rhythm reaction to functional tests typical of research participants of the same age but belonging to different puberty phases and having different levels of physical development are presented in fig. 1.

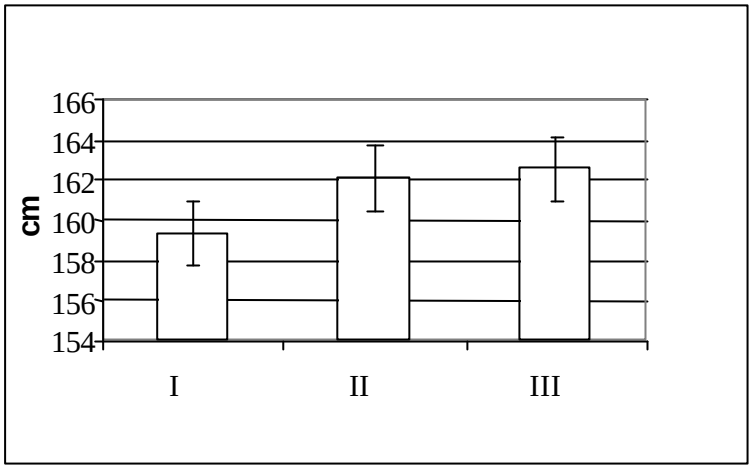

Fig.1.

Body height in different puberty groups

An analysis of physical development indicates that both height and body mass variables are lowest in the group of girls belonging to the first puberty phase (fig. 1 and 2). Body height differs to a small extent, and differences among all the groups researched are not statistically significant. A comparison of body mass among groups shows that girls from group 1 (first puberty phase) have a significantly lower body mass ($p<0.05$), than those belonging to the second and third puberty groups. Third puberty phase girl's body mass values are highest, yet they are not significantly different from those typical of group 2.

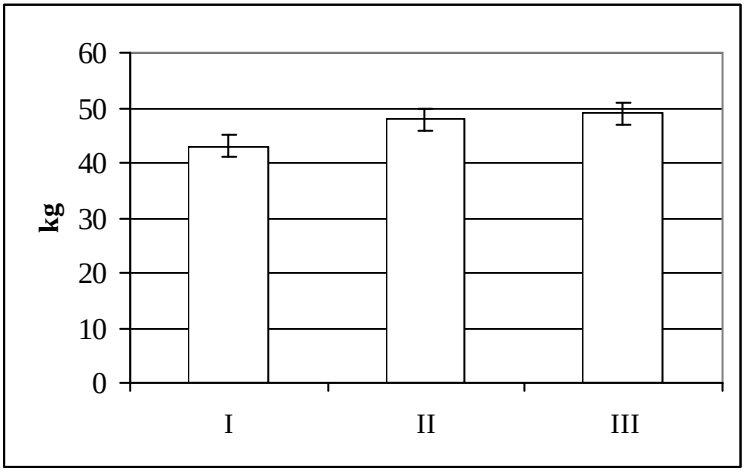

Fig. 2.

Body mass in different puberty groups

An overview of physical development analysis allows to state that girls belonging to the group of early puberty (group 3) have higher physical development variables than those belonging to late puberty groups (2 and 3), especially in terms of body mass. It is likely that earlier beginning of group 3 girls' puberty activated their metabolic processes to a greater extent, thus accelerating their physical development, despite similar age of all researched participants.

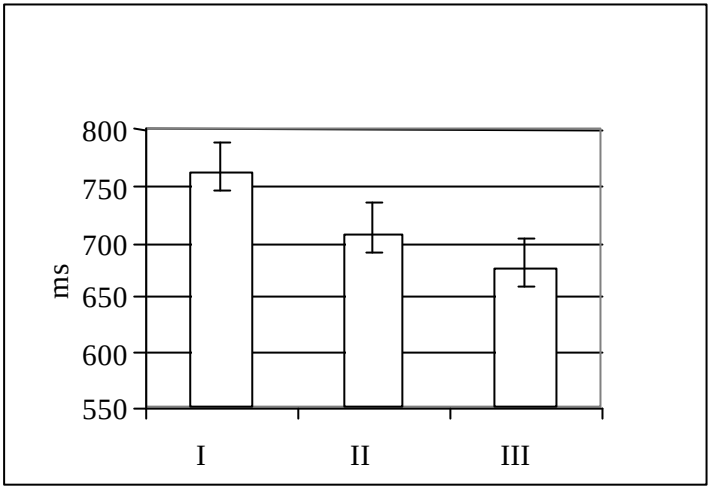

Fig. 3.

Heart rhythm (RF) variables in different puberty groups

According to physical development variables, girls with accelerated puberty (3) exceed those belonging to late puberty groups (2 and 3), yet analysis of the obtained heart rhythm variables recorded while at rest and during functional tests indicate contrary tendencies. The performed comparison between heart rhythm frequency variables of all three groups in a horizontal position while at rest (fig. 3) indicate that the lowest heart rhythm frequencies are typical of girls with slowest puberty (group 1), i.e. the longest average RF intervals (RF=761.54±28.51 ms) are typical of group 1, while the highest heart rhythm frequency is observed in the early puberty group (group 3), where average RF intervals are shortest (RF=675.80±16.08 ms) and differ significantly from group 1 ($p<0.025$). The RF variables obtained in the second group of participants in the horizontal position while at rest are in between those of group 1 and group 3, yet there is no statistical significance.

An analysis of general heart rhythm dispersion (RD) variable indicates that the highest RF interval inequality is noticeable in the first group of participants (RD=48.15±3.72 ms). Meanwhile, the third group results are (RD=38.73±3.03 ms).

Yet RD differences among all the groups analyzed are not statistically significant.

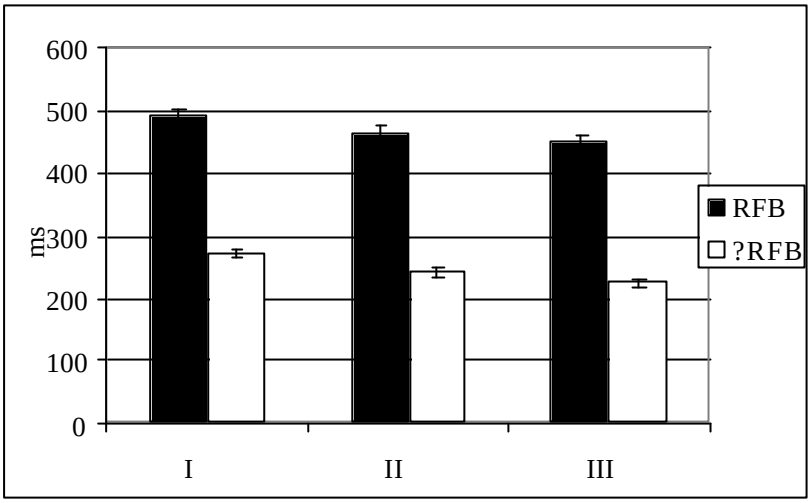

Fig. 4.

Maximal rhythm frequency increase (RF_B) and amplitude rhythm reaction ($?RF_B$) variables during active orthostasis in different puberty groups

A general overview of heart rhythm frequency (RF) and general rhythm dispersion (RD) analysis indicate that the lowest rhythm frequency and the highest rhythm dispersion are typical of the late puberty group of females (group 1), while the most frequent and stable rhythm is observed in the group of early puberty (phase 3). Faster physical development during early puberty leaves behind the development of the main functional systems of the body. As can be seen from the presented results, more stable and more frequent heart rhythm of early puberty (group 3) girls indirectly reflects lower functional capacity of their cardiovascular systems in comparison with those of late puberty.

A spectral analysis of heart rhythm (fig. 5) indicates that absolute values (ms) of very low frequency components (VLFC) differ little among the researched groups. Early puberty group of girls (group 3) have VLFC values higher than those obtained in other groups (VLFC=21.47±1.96 ms). Meanwhile, the lowest values of the aforementioned variables are observed in group 2 (VLFC=18.25±0.95 ms). A comparison of percentile slowest period wave variables (fig. 6) shows that this component takes the greatest relative percentile part in the heart rhythm spectra in early puberty (NVLFC=35.53±4.76 %), while it is lowest in late puberty (NVLFC=20.15±1.94 %). The NVLFC percentile variable of group 3 is significantly higher than those obtained in groups 2 ($p<0.05$) and 1 ($p<0.01$).

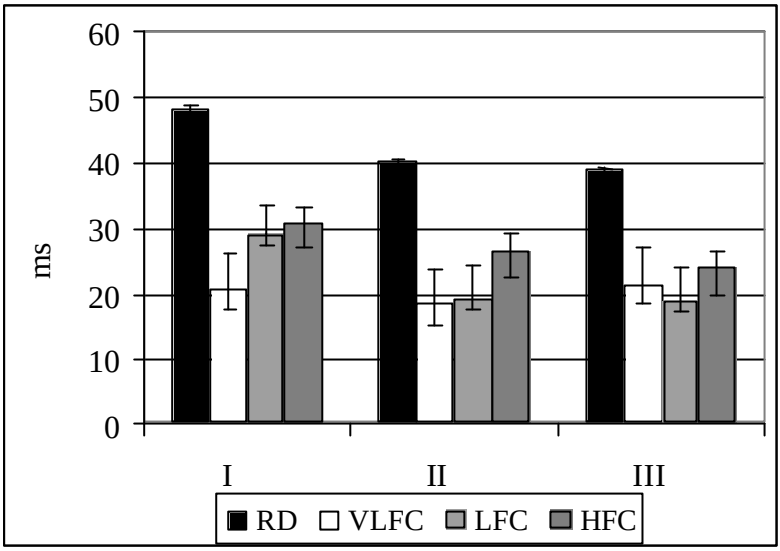

Fig. 5.

General heart rhythm dispersion (RD) in the area of very low (VLFC), low (LFC) and high (HFC) rhythm waves recorded in different puberty groups (ms).

Meanwhile, absolute values of the low frequency component (LFC) reflect a contrary situation. The variable of waves belonging to this period has the highest value in the late puberty group (LFC=29.00±3.25 ms). At the same time, it manifests the lowest values in group 3 – the early puberty group (LFC=18.93±2.21 ms). It should be stressed that the LFC value obtained in group 1 is significantly lower ($p<0.025$) than the LFC values obtained in groups 2 and 3. The percentile part of waves belonging to this period (NVLFC) also have the highest values in group 1 (NLFC=35.15±2.85 %), while it is much lower in groups 2 and 3, although it only differs significantly from those obtained in group 2 ($p<0.01$). High frequency component values, both absolute and relative, manifest no statistically significant differences among the researched groups.

A general overview of the differences among the girls belonging to different puberty phases in both absolute and relative variables of the waves allows to state that the parasympathetic and sympathetic sections of the autonomic nervous system take different relative parts in autonomic heart rhythm control. Considering the fact that parasympathetic and sympathetic nervous system have approximately equal parts in case of slowest puberty girls (group 1), a dominance of the sympathetic autonomic nervous system gains prominence in the background of the decreased part of the parasympathetic autonomic nerv-

ous system in case of group 2 and especially group 3 consisting of girls with early puberty.

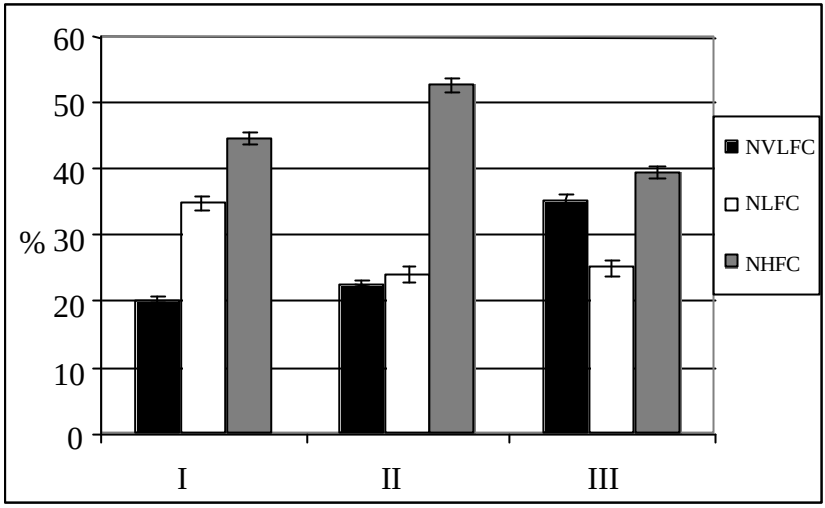

Fig. 6.

Very low (NVLFC), low (NLFC) and high (NHFC) frequency waves recorded in different puberty groups (%).

Functional test variables, i.e. those recorded during active orthostasis and during the Roufier test are the best in group 1 – the slow puberty group (RF_B=490.92±8.94 ms; ? RF_B=271.38±25.64 ms; IR=9.35±0.83 s per unit). They are worst in group 3, i.e. the group of fastest puberty (RF_B=450.13±9.20 ms; ? RF_B=225.47±13.33 ms; IR=12.08±0.90 s per unit). Statistically significant RF_B differences can only be noticed when comparing groups 1 and 3 ($p<0.01$). ? RF_B variable differences among groups are low and have no statistical significance ($p>0.05$), while IR, as well as ? RF_B variables; only differ significantly when compared to groups 1 and 3.

Conclusions

1. Girls with late puberty, when compared to those of early and normal puberty, have more prominent autonomic control of heart rhythm, what determines lower heart rhythm frequencies and the greater dispersion of it at rest and the most prominent heart rhythm reaction during functional orthostatic tests as well as the highest values of the functional Roufier test. Such a situation reflects a higher level of functional heart capacity of girls with late puberty.

2. During adolescent physical education, and female sports training, biological maturity should be evaluated. Such procedures would help in avoiding the application of inadequate training loads.

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