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INDIVIDUAL GROWTH PATTERNS AND PHYSICAL FITNESS IN RIGA SCHOOLCHILDREN

Introduction

Growth and development are related concepts. Growth refers to the increase in the total length of the body dimensions. Development, on the other hand, refers to the tempo and timing of progess towards the mature biological state. Physical growth represents a biologic process which is determined by environmental, social and genetic factors. From generation to generation there are changes of the anthropometric, morphometric and integrative functional parameters. Physical development characterises the health of the growing organism and the process of its formation and maturation in accordance with the biological age and morphofunctional state at any period of growth. In addition, the development of the functional relations between the different systems has also been changed. Growth of the organism, its systems and organs can be characterized first of all by its velocity duration. Velocity, better than body height, represents the condition of the children at any period of growth [15]. The processes underlying growth and development are quite plastic and respond to a variety of conditions in the environments in which children are growing up. Intensity of growth of different systems and organs in the organism differs and is determined by the genotype. This is confirmed by a significant variety of the onset of the pubertal spurt. Cross-sectional studies are not appropriate for quantifying the timing and tempo of the growth spurt. Individuals pass through adolescence at their own pace and consequently have their growth spurts over a wide range of the so-called time-spreading effect [15]. The longitudinal measurements would provide a better representation of the impact of human growth patterns [7] and timing of spurts in a variety of characteristics [2].

The purpose of our longitudinal study was to determine idividual growth patterns of the somatic development and physical fitness in Riga's schoolchildren at the ages 7 to 16 and compare them with the previous investigations in Riga and Europe.

Subjects and methods

The study represents 1041 observations of the schoolchildren at ages 7 to 16 years over a 10-year period. More than 120 schoolchildren, most of them born in 1970, of Riga Secondary School were observed. They represented a typical, due to social-economic

conditions homogenous and practically healthy group. About 40 of them dropped out for different reasons. Investigations were conducted annualy in autumn (September-October) after summer holidays, in the same laboratory and by the same investigators. Monitoring of anthropometric dimensions include: body height and weight, chest circumference. Nonsmoothed percentiles of height (cm), weight (kg) and growth rate or velocity, cm . year $^{-1}$ and kg . year $^{-1}$ were estimated. Subscapular skinfold thickness, level of habitual daily physical activity (HLPA) and physical fitness were determined at ages 14–16. HLPA was fixed by a questionare. Physical fitness was characterized from the results in running tests at a distances of 300 and 500 m, 2 and 3 km. Along the whole study period physical performance was recorded according to the last level in bicycle test with incremental increase of work load. The parameters obtained in all subjects under study were computed seperately for girls and boys, and statistical analyses were made: group means (+ - SD), linear correlations and regressions were calculated.

Results

The growth of body height and weight in nonsmoothed percentile values at the ages 7 to 16 are shown in Figures 1a, b and 2a, b and average values of the height, weight and chest circumference of schoolchildren during the observed period are represented in Table 1.

Repeated questionnaires of 54 girls and 55 boys aged 14–16 revealead three levels of habitual physical activity: active in 11% of cases in girls and 36% of cases in boys; medium in 46% and 40%, and low in 42% and 24% of cases, respectively. The average values of height, weight, chest circumference, body fat and submaximal physical performance on bicycle in subjects with different HLPA did not differ statistically. Adolescents with different HLPA formed different physical fitness levels according to the running records: high in 23% of cases in boys and girls, good – 48% of boys and 46% of girls, average and bad in 29% and 31%, respectively. The level of physical fitness in shoolchildren was decisive for the last work load in stepwise submaximal bicycle test ($p < 0.01$).

The individual growth pattern for height may have some acceleration during the period between 7–16 years of age: one spurt was characteristic for 44 girls (74.6%) and 42 boys (73.7%). Two accelerations during observed period had 13 girls (22%) and 14 boys (24.6%), three – 3 girls and 1 boy. Individual variation in the timing and tempo of the adolescent spurt were available for subjects with one spurt. "Timing" refers to the CA at which the spurt occurs, while "tempo" refers to the rate at which an individual goes through the spurt. In addition to documenting the occurance of adolescent spurts in performance, the timing of the spurts is ordinarily viewed relative to the timing of peak height velocity (PHV), i.e. relative to a biological age, rather than to CA. Longitudinal data show well - defined adolescent spurts in the height and weight (Figure 3). Peak height velocity has been found in 73% of girls at the ages 11–13 and in 87% of boys at the ages 13–15. Peak

Table 1. Average values for body height, weight and chest circum ference in schoolchildren during observed period (Means ± SD).

Sex / Age		PHV, cm/year	References, year
Female	11-12	6.66	Jēruma-Krastiņa, 1937
Female	12.2 ± 1.2	8.2 ± 2.2	Aberberga – Augškalne, 1990
Female	12.1 ± 0.9	9 ± 1.03	Tanner et al., 1966
Female	12.6	6.7 ± 0.2	Kemper et al., 1985
Male	12 –13	8.82	Jēruma-Krastiņa, 1937
Male	13.7 ± 1.1	9.7 ± 2.3	Aberberga – Augškalne, 1990
Male	14.1 ± 0.9	10.3 ± 1.5	Tanner et al., 1966
Male	14	9.6 ± 0.2	Kemper et al., 1985
Male	13.6	9.4	Vanden Eynde et al., 1981
Male	14.67 ± 1	10.1 ± 1.16	Sprynarova et al., 1987
Sex / Age		**PWV, kg/year**	**References, year**
Female	11 –12	5.62	Jēruma-Krastiņa, 1937
Female	13.3 ± 1.4	8.5 ± 3	Aberberga – Augškalne, 1990
Female	12.9 ± 1.1	8.8 ± 1.5	Tanner et al., 1966
Male	12 –13	8	Jēruma-Krastiņa, 1937
Male	13.8 ± 1.2	10.1 ± 3.7	Aberberga – Augškalne, 1990
Male	14.3 ± 0.9	9.8 ± 2	Tanner et al., 1966
Male	14.1 ± 1.1	8.5 ± 3	Vanden Eynde et al., 1981
Male	14.6 ± 0.98	10.1 ± 3.7	Sprynarova et al., 1987

weight velocity (PWV) in 58% of girls at ages 13–14 and in 64% of boys at ages 14–15. The most intensive increase in weight/height index by 43.9 20.3 g/cm in girls has been found at the age of 13.3±1.4 years and by 45.9±19.3 g/cm in boys at the age of 13.5±1.3 years. At the age of PHV the relationships with height ($r = 0.79$), weight ($r = 0.89$) and chest circumferential ($r = 0.56$) was proportional. Regular menarche takes place on average at age 14.07±0.96 ($v = 6.8\%$), minimal age 11.5 years, maximal 15.5 years and two missed until 16. Correlation coefficients between the age of regular menarche and PHV was 0.40 and between the age of regular menarche and PWV was 0.32 ($p < 0.05$).

Physical performance according to the last level in bicycle test with increasing biological age increased too, more marked in boys. Average increase in work load of the last step in bicycle test before PHV in schoolchildren was 14–17 W, after spurt 6–9 W. The most intensive increase in physical performance due to the last step of bicycle test in girls was two years before PHV (20 W) and at the year after PHV (16 W); in boys a year before and after PHV (24 Watt). Close correlation was

Table 2. Peak velocities of somatic development of Riga and European children (Mean ± SD).

Sex / Age		PHV, cm/year	References, year
Female	11-12	6.66	Jēruma-Krastiņa, 1937
Female	12.2 ± 1.2	8.2 ± 2.2	Aberberga – Augškalne, 1990
Female	12.1 ± 0.9	9 ± 1.03	Tanner et al., 1966
Female	12.6	6.7 ± 0.2	Kemper et al., 1985
Male	12 –13	8.82	Jēruma-Krastiņa, 1937
Male	13.7 ± 1.1	9.7 ± 2.3	Aberberga – Augškalne, 1990
Male	14.1 ± 0.9	10.3 ± 1.5	Tanner et al., 1966
Male	14	9.6 ± 0.2	Kemper et al., 1985
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Sex / Age		**PWV, kg/year**	**References, year**
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Female	12.9 ± 1.1	8.8 ± 1.5	Tanner et al., 1966
Male	12 –13	8	Jēruma-Krastiņa, 1937
Male	13.8 ± 1.2	10.1 ± 3.7	Aberberga – Augškalne, 1990
Male	14.3 ± 0.9	9.8 ± 2	Tanner et al., 1966
Male	14.1 ± 1.1	8.5 ± 3	Vanden Eynde et al., 1981
Male	14.6 ± 0.98	10.1 ± 3.7	Sprynarova et al., 1987

revealed between the last work load in bicycle test and PHV in girls ($r = 0.88$) and in boys ($r = 0.91$). The higher the tempo at PHV in girls, the better the physical fitness ($r = -0.73$); in boys these relationships were weaker ($r = -0.20$).

Comparing the individual dynamic of growth and development of the organism with the chronological age of the subjects and age at PHV, we singled out early maturers, midmaturers and late maturers. Age at PHV in midmaturers was in the range from 11.2–13.2 years in 60% of girls and from 12.7–14.7 years in 78% of boys. Early maturers were 18% of girls and 15% of boys, late maturers 2.2% of girls and 7% of boys, respectively. Tempo of the adolescent spurt in girls ($p < 0.05$) midmaturers was 8.2±2.3 cm/year, early maturers 9.4±1.7 cm/year, late 7.2±1.9.0 cm/year, on the average. In boys 9.9±2.0 cm/year; 8.3±2.9 cm/year; 9.7±4.0 cm/year, respectively. Of late maturer boys, some acceleration in height growth two years before PHV was also observed. Girl early maturers were taller in earlier CA if compared with late maturers. Regular menarche in early maturers took place 1.5 years earlier (13.0±0.6 years of age) if compared with late (14.5±0.7 years of age)

and 1 year earlier if compared with midmaturers (14.0±0.9 years of age). At the age of 14 menarche was missed in 7 girls, at the age of 15 in 5 girls and 4 of them were late maturers. We have observed the relationship between the tempo of the adolescent spurt in girls and menarche: most pronounced tempo, earlier menarche.

We noted that at every stage of the somatic development due to the biological age there were less absolute values for height in early maturers and higher values for late maturers, most marked in girls. Girl late maturers had lower tempo at PHV, higher absolute values for height and longer timing for PHV. In spite of different timing and tempo in somatic developing in schoolchildren, at the ages 15-16 there was no significant difference ($p>0.05$) in absolute values for height. At 16 years of age in girls, average values of height in early maturers was 165.2±3.4 cm, midmaturers 165.8±4.1 cm and late 168.5±1.7 cm. In boys 185.0±0.1 cm, 182.3±5.4 and 175.3±13.3 cm, respectively. Different weight/height index at the year of PHW has been found in schoolchildren with different individual timing. In early maturer girls it was 248.3 43 g/cm, in medium maturers 277.8±41.6 g/cm, late 311.6±45.7 g/cm. In boys 269.0±36.8 g/cm, 345.2±47.7 g/cm, 332.3±33.8 g/cm. At the age 16 weight-height index is lower in early maturer girls and late maturer boys. Our data revealed significant role of the different individual timing and tempo of somatic growth for health of the schoolchildren when reaching the values of adult organism. Early maturers had such risk factors as low HLPA (3.3±1.5 points; 8 points - active) and highest morbidity (1.5±0.9 illness/year over study period) if compared with others.

Discussion

Average values of body height, weight and chest circumference exceed (more marked in boys) the obtained data for Riga's children in 1936 [21], 1937 [22], 1958 [20], 1977 [23]. In boys height, weight increase at the ages 8–16 if compared with data published in 1936 were 9.07 cm and 7.48 kg, on average; and if compared with 1977 they were 3.74 cm and 3.81 kg ; in girls 5.58 cm and 1.18 kg; 1.18 cm and 1.38 kg, respectively. There was increase in chest circumferential dimentions too, more marked if compared with 1936. The same dynamic for total body lengths were observed by [17] and revealed the impact of the growth acceleration. The most pronounced variability of differences due to exceeded average values obtained in our children and data published earlier was at the ages 12–14 (data published in 1936) both in boys and girls and at the ages 13–15 (1937 and 1977) for boys and 12–14 for girls (1937 and 1977) which corresponded to the age of the most intensive morphofunctional restructuring of the organism when activation of the hypothalamicpituitary-gonadal axis and the acquisition of adult body composition and habitus take place. Regular menarche, indicator of female puberty, established at the age 14.07±0.96 in girls is in agreement with data published in Riga in 1933 and 1977. 80% of the girls attained menarche in Leuven growth study (Flemish girls) at 14 years and mean ages at menarche in several European girls are within the range of 12.6–13.4 years of age [11].

Figure 1a. Nonsmoothed percentile for body height: girls

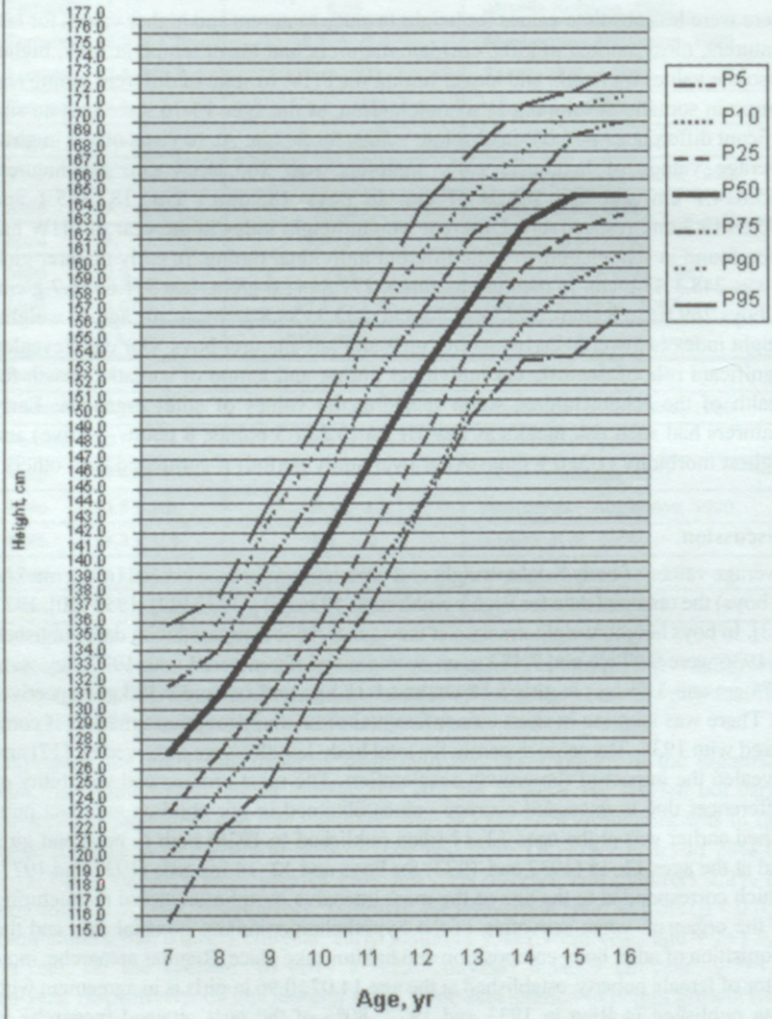


Figure 1b. Nonsmoothed percentiles for body hight: boys

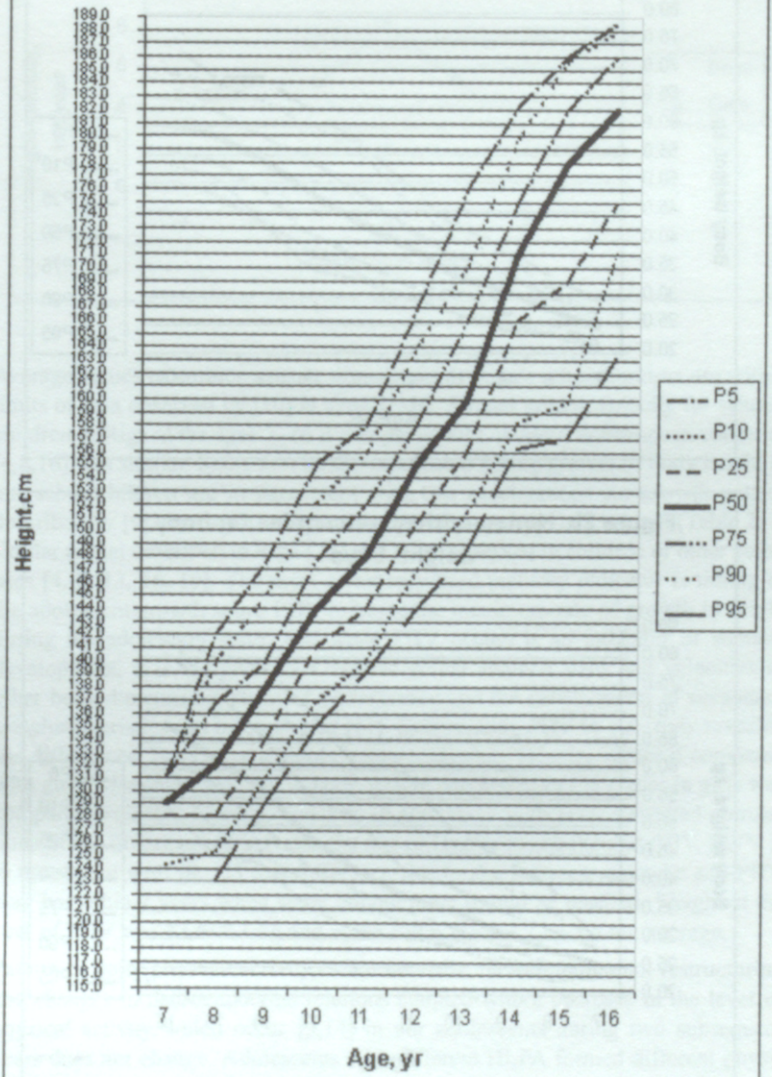


Figure 2a. Nonsmoothed percentiles for body weight: girls

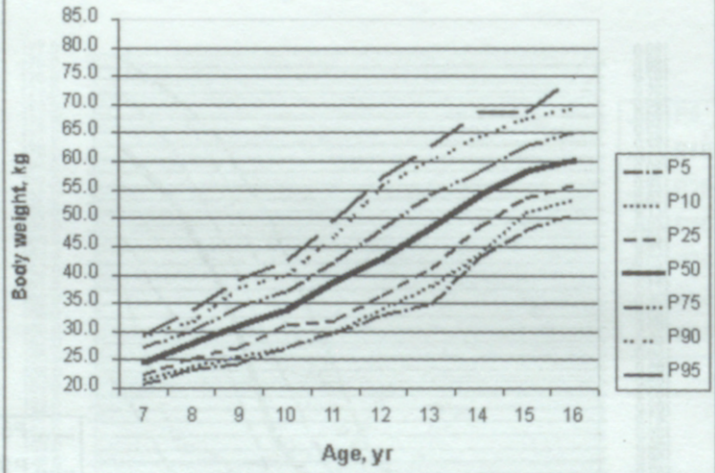
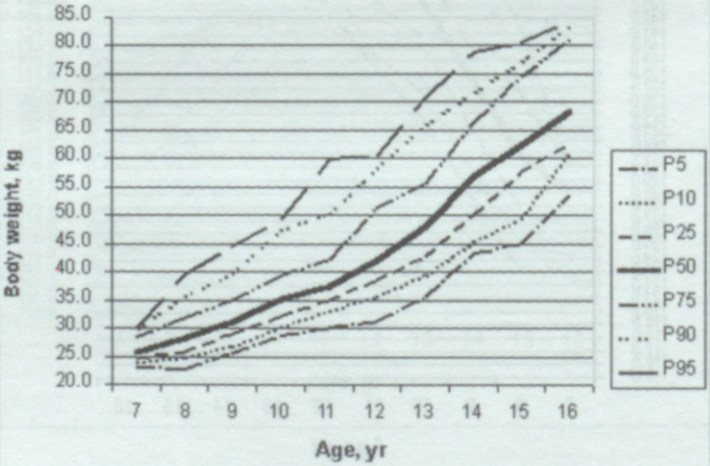
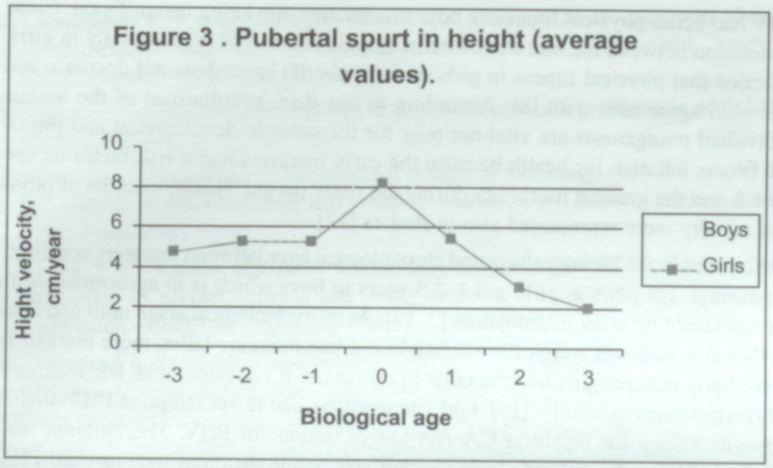


Figure 2b. Nonsmoothed percentiles for body weight: boys





Average values of anthropometric dimensions in Riga's schoolchildren are within limits of data observed by [10] at ages 11–16. Annual growth velocity for schoolchildren in Riga at the ages 7–16 if compared with children in European countries [4,8,16] was similar. Some accelerations revealed during growth of body height in our schoolchildren are in agreement with two accelerations for growth pattern described by [9]. Average timing and tempo of growth in our children (Table 2) is similar to that described in Riga [22] and those observed in children of other countries [4, 8, 13, 16, 19]. The most commonly used maturity indicator is timing of the adolescent growth spurt. PHV refers to the maximum rate of growth in height during the adolescent spurt, and when PHV occurs is an indicator of somatic development, it is the land mark against which attained sizes and velocities of other body dimensions, physical performance and the development of secondary sex characteristics can be expressed [11]. Data relating PHV in our study revealed sex differences. Boys have a higher tempo – absolute velocity values if compared with girls. Maximum velocity in body weight occured after PHV later in girls was compared with that of boys, which is in agreement with [11]. Revealed correlations in our investigation between the age of regular menarche and PHV, PWV is in agreement with [8, 11] that difference due to age between menache and PHV may be within 2 years when some critical mass should be reached. Weight at the year of PHV was 43.6±8.1 kg and at the PWV 49.2±4.7 kg, on the average.

Pattern of daily physical activity, when intensive morphofunctional restructuring and changes in neuroendocrine relations coupled with a decrease in the level of physical activity which occur [5,14] in our adolescents during two subsequent years does not change. Adolescents with different HLPA formed different physical fitness levels which were decisive for physical performance. Girls with greater

PHV had better physical fitness, in boys this relationship being insignificant. Close correlation between the last work load in bicycle test and PHV, especially in girls, revealed that physical fitness in girls during pubertal spurt does not decrease and this is in agreement with [8]. According to our data, peculiarities of the unique individual ontogenesis are vital not only for the somatic development and physical fitness but also for health because the early maturers had a risk factor as low HPLA and the greatest morbidity during the study period. Health benefits of physical activity were represented also in studies [12].

Differences in the biological age and chronological ages between maturers constitute on average 1.7 years in girls and 1–2.5 years in boys which is in agreenment with data obtained by other investigators [3, 17]. At every biological stage until and after PHV, early maturers were of lower height but late maturers taller, more marked in girls. Early maturer girls became taller in earlier CA if compared with late maturers. This was observed also by [15]. Girl late maturers had lower tempo at PHV, higher absolute values for height at CA and longer timing for PHV. The children who reached PHV early are also closer to adult size, while the child who reached PHV later are further from adult size [11]. Regular menarche in our study in early maturers took place 1.5 years earlier if compared with late ones. In spite of the different timing and tempo in individual somatic development in Riga's schoolchildren, at the ages of 16 the absolute values for height reached the soze of young adults [6, 10].

Conclusion

The obtained data on the timing and tempo of somatic development of the schoolchildren in Riga, observed during the period of 1978–1987 revealed continuous increase in longitudinal and circumferencial measurements of the body due to the growth acceleration in relation with data published in 1936, 1937, 1977 and do not significantly differ from the data published by scientists in other Europeen countries concerning the same age and sex groups. Representing percentile values should be easy to use in evaluating the growth status of children in Riga.

Size of the body attained at a given age, rates of growth and the timing of adolescent growth spurt vary among children affecting not only physical fitness but also their health due to risk factors - low HPLA and morbidity. Adolescents with different HLPA formed different physical fitness levels which were decisive for physical performance in the bicycle test.

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