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Tracking of Anthropometric Parameters and Bioelectrical Impedance in Pubertal Boys and Girls

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ABSTRACT

The aim of this study was to investigate the anthropometric parameters and body impedance once per year during four years of the pubertal period in Estonian children. In total, 81 boys and 86 girls aged 10–11 years at the beginning of the study were investigated. Pubertal status was self-assessed by sexual maturation stages according to Tanner[18] and physical activity index (PAI) according to Telama et al.[17]. Body height and weight were measured and body mass index (BMI) calculated. In total, 9 skinfolds, 13 girths, 8 lengths and 8 breadths/lengths were measured according to the protocol of the International Society for the Advancement of Kinanthropometry[21]. Somatotype components were estimated according to the method of Carter and Heath[9]. Body impedance was measured using Multiscan 5000 (Bodystat, UK) and the impedance index (height^2/impedance) was calculated. The tracking of body height, weight, BMI, skinfolds, girths, lengths, breadth/lengths and body impedance was high (as a rule $r \geq 0.9$). By increasing the time period, the correlation slightly decreased. In contrast, tracking correlations for PAI and Tanner stages were significant but quite low. Increase in mean body height was highest between 12–13 years of age (6.9 cm per year) in boys and in girls between 11–12 years of age (6.3 cm per year). In boys and girls, the peak increase in body weight was between 11 and 12 years of age, 5.7 kg and 5.2 kg, respectively. With the increasing age, body impedance decreased and impedance index increased. In conclusion, our results indicate that during puberty the detailed anthropometric parameters and body impedance tracked highly. However, the tracking of PAI and Tanner stages was significant but relatively low.

Key words: *anthropometry, somatotype, bioelectrical impedance, sexual maturation, tracking*

Introduction

Understanding and quantifying changes in anthropometric measures and body composition during pubertal period, and associated factors, would facilitate the early recognition of children with aberrant charges and/or unusual levels of body composition. There is a tremendous number of studies where the different anthropometric parameters and/or body composition have been investigated in children using different measurement methods. However, there are a few data about the tracking of these parameters during the pubertal period and the effect of the rate of biological maturation on anthropometry and body composition.

Such body composition measures as body mass index (BMI), sum of skinfolds, and relative weight have been found to track significantly from childhood to adulthood[1,2]. However, tracking coefficients have been found to be higher over shorter time intervals and for BMI compared with those for skinfolds and relative weight measures. For example, the tracking correlations for BMI have ranged from r=0.77 to r=0.89 over 4- to 8-year time intervals[3] and from r=0.44 to r=0.84 over 13- to 15- year time intervals[4]. Several authors[5,6] have found that skinfolds tracked significantly from approximately 9 to 16 years of age. The tracking correlations between 9 and 13 years and 9 and 16 years of age ranged from r=0.68 to r=0.76 and r=0.64 to r=0.72, respectively[5,6]. The Fels Longitudinal Study[7] indicated that changes in childhood BMI were related to adult overweight and adiposity more in females than males. In a 3-yr longitudinal study (ages 9 to 12), the results suggest that BMI and skinfold thick-

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nesses are more likely to track during early adolescence[8]. Relative weight during childhood is a poor correlate of relative weight in adulthood[2]. However, it is well known that tracking correlations have been found to be higher over shorter time intervals. There is a lack of information about the tracking of other anthropometric parameters (girths, lengths, breadths/lengths) in children of different nationalities during puberty.

The somatotype which is a quantification of the present shape and composition of the human body has shown that both individual and group somatotypes change with age[9]. As a rule, during puberty, the somatotypes change dramatically and often reverse component dominance more than once[10,11]. However, Claessens et al.[12] have observed a relatively high degree of constancy in body build during the growth period despite marked fluctuations in body dimensions.

Bioelectrical impedance analysis (BIA) is a frequently used method for estimating body composition in children[13,14,15]. Several equations have been developed for the prediction of different parameters of body composition. Little is known about the longitudinal changes of bioelectrical impedance during pubertal time. However, using group-specific BIA equations, Phillips et al.[16] recently concluded that BIA provided accurate estimates of the change in both fat free mass and body fat% over time in adolescent girls.

We hypothesized that different anthropometric parameters (skinfolds, girths, lengths, breadths/lengths) change differently during puberty. It was predicted that the somatotype components will track better than single anthropometric parameters. The aim of this study was to investigate the anthropometric parameters and body impedance once per year during four years over puberty in Estonian public secondary school boys and girls.

Materials and Methods

In total, 81 boys and 86 girls of the age 10–11 years at the beginning of the longitudinal study have been investigated. They were studied once a year in January and February for four consecutive years. All children participated at all four measurement time-points. The subjects were studying at several public secondary schools of Tartu (Estonia) and all children were of Estonian origin. The children were healthy and non-obese. Their school physical education consisted of two obligatory physical education (PE) classes per week. The physical activity index (PAI) of children was estimated by self-administration at school during a PE class time according to the questionnaire of Telama et al.[17]. The filling in of the questionnaire took about 15 minutes. All children, parents and teachers were thoroughly informed of the purposes and contents of the study and written informed consent was obtained from the parents or the adult subjects before participation. This study was approved by the Medical Ethics Committee of the University of Tartu (Estonia).

Measurements were performed at school in the morning. All children had a light traditional breakfast. The children did not exercise before being tested. The pubertal status of the subjects was assessed according to the descriptions of the stages given by Tanner[18]. The self-assessment method for the evaluation of pubic hair was used. Each subject was asked to observe photographs[19,20] of the stages of secondary sex characteristics and also to read the descriptions of stages. Measurements on each child were made in the same day.

Body height was measured using a Martin metal anthropometer in cm (±0.1 cm) and body weight with medical scales in kg (±0.05 kg) and body mass index (BMI, kg/m^2) was calculated. In total, nine skinfolds (triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, medial calf, mid-axilla), 13 girths (head, neck, arm relaxed, arm flexed and tensed, forearm, wrist, chest, waist, gluteal, thigh I, thigh II, calf, ankle), eight lengths (acromiale-radiale, radiale-stylion, midstylion-dactylion, iliospinale box height, trochanterion, trochanterion-tibiale laterale, tibiale laterale to floor, tibiale mediale-spy-tibiale) and eight breadths/lengths (biacromial, biiliocristal, foot length, sitting height, transverse chest, A-P chest depth, humerus, femur) were measured according to the protocol recommended by the International Society for the Advancement of Kinathropometry (ISAK)[21]. Skinfold thicknesses were measured in triplicate using Holtain (Crymmych, UK) skinfold calipers. For each skinfold, the mean of all three trials was taken as the final measurement. The CENTURION KIT instrumentation (Rosscraft, Surrey, BC, Canada) was used for girth, length and breadth/length measurements. Calibration of all equipment was conducted prior to and at regular intervals during the data collection period. The three series of anthropometric measurements were taken by the same (A. L.) well-trained anthropometrist (Level 1 ISAK anthropometrist). Technical errors were for skinfolds between 0.9 mm and 1.6 mm and for length and girth values <10 mm. Somatotype components – endomorphy, mesomorphy and ectomorphy were calculated according to the Carter and Heath[9] protocol.

Body impedance was measured on the right side of the body using a multiple-frequency impedance device (Multiscan 5000, Bodystat, UK) at standard conduction current of 800 μA and 50 KHz and the impedance index was calculated (height^2/impedance). The accuracy of the equipment was checked before the measurements with a 500 Ω resistor supplied by the manufacturer. Children were placed in a supine position with limbs slightly abducted. Skin current electrodes were placed on the dorsal surface on the hand and foot at the metacarpals and metatarsals. Skin was cleaned with 70% alcohol and a small drop of ECG cream was used to improve current conduction between the electrode and skin. Because of the fact that there are no specific regression equations available for Estonian children, body fat% and fat-full mass were not calculated. The hydration state of the children was not well controlled. They were tested in school on the mornings after a light breakfast at home. The children did not exercise before testing. High intraclass correlation coefficients (ICC>0.979) demonstrated excellent test-retest (between week) measurement reliability for BIA method.

Data analysis was performed using SPSS 10.0 for Windows (Chicago, IL). Standard statistical methods were used to calculate mean and standard deviation (X±SD). The interperiod Spearman correlations were used as tracking coefficients. All time points correlated with the baseline measure and additionally, between the second, third and fourth, and the third and fourth measurements. Significance was set at $p<0.05$.

Results

Basic anthropometric parameters, somatotype components, PAI and Tanner stage results are presented in Table 1. Body height and weight increased significantly ($p<0.05$–0.01) during each year both in boys and girls. However, increases in BMI of the girls between the third and fourth measurement was not significant ($p>0.05$). From the somatotype components, ectomorphy did not change significantly during the study period. In boys, the endomorphy was lowest at the first measurement ($p<$ 0.05–0.01). In girls, the changes were not significant ($p>0.05$). Mesomorphy in boys did not change significantly; in girls, the index was significantly higher during the first measurement. The PAI did not change significantly during the pubertal period. The assessment of Tanner stage increased significantly ($p<0.01$–0.001) every year.

All the measured skinfold thicknesses increased significantly between the first and second measurement (data not presented). At the end of puberty, especially in boys, some skinfold thicknesses decreased. Except that of the head, as a rule, other girths increased significantly. There were more significant increases in length and breadth/length parameters at the end of puberty (between the second and third, and the third and fourth measurements).

Tracking of the body height (in boys r=0.938–0.986; in girls r=0.912–0.987), body weight (in boys r=0.905–0.957; in girls r=0.906–0.979) and BMI (in boys r=0.828–0.943; in girls r=0.814–0.926) was very high (Table 2). The tracking coefficients for somatotype components were also relatively high: ectomorphy (in boys r=0.817–0.933; in girls r=0.861–0.970), endomorphy (in boys r=0.693–0.901; in girls r=0.866–0.947) and mesomorphy (in boys r=0.780–0.882; in girls r=0.819–0.912). The tracking of the PAI was relatively low (in boys r=0.272–0.446; in girls r=0.252–0.581). Compared with PAI, the tracking of Tanner stages was slightly higher (in boys r=0.314–0.683; in girls r=0.354–0.722).

The interperiod Spearman correlation coefficients of skinfold thicknesses were relatively high (Table 3). However, by increasing the time intervals between the measurements, the tracking coefficients decreased rapidly. As a rule, over four years (from 10 to 13), the tracking coefficients decreased about 0.2 units (Table 3). The tracking of the girth was quite high and the differences between the years were relatively low (Table 4). Normally, the changes in four years were relatively stable. Similar changes were observed for the length parameters (Table

TABLE 1
ANTHROPOMETRIC PARAMETERS, SOMATOTYPE COMPONENTS, PAI (PHYSICAL ACTIVITY INDEX) AND TANNER[19, 20] STAGES DURING FOUR YEARS (UPPER LINE BOYS AND LOWER LINE GIRLS, X±SD)

	First measurement (10-year-old)	Second measurement (11-year-old)	Third measurement (12-year-old)	Fourth measurement (13-year-old)
Age (yrs)	10.0±0.8	10.9±0.8	12.0±0.8	12.9±0.8
	9.9±0.7	10.8±0.8	11.9±0.8	12.8±0.8
Height (cm)	142.8±7.3	148.5±7.8	155.1±8.9	162.0±10.2
	141.7±7.4	147.5±8.2	153.8±8.0	159.0±7.6
Weight (kg)	34.8±5.6	39.3±7.2	45.0±9.2	50.2±10.8
	33.4±6.6	37.2±7.9	42.4±9.2	46.4±9.6
BMI (kg/m²)	17.0±1.8	17.7±2.1	18.5±2.7	19.0±2.8
	16.5±2.2	17.0±2.4	17.9±3.0	18.2±2.8
Endomorphy	2.1±0.9	2.7±1.2	2.6±1.5	2.5±1.4
	2.6±1.3	2.8±1.6	2.8±1.5	2.9±1.5
Mesomorphy	4.2±0.9	4.1±1.1	4.3±1.1	4.3±1.2
	3.8±0.9	3.5±0.9	3.5±1.0	3.3±1.0
Ectomorphy	3.5±1.1	3.5±1.3	3.6±1.4	3.8±1.4
	3.8±1.3	4.0±1.4	3.9±1.4	4.0±1.4
PAI	11.7±1.4	11.7±1.5	11.8±1.3	11.8±1.5
	11.6±1.8	11.8±1.4	11.9±1.4	11.8±1.6
Tanner stage	1–2	1–3	2–4	2–4
	1–3	2–4	2–4	2–4

PAI – physical activity index, BMI – body mass index

TABLE 2
INTERPERIOD SPEARMAN CORRELATION COEFFICIENTS OF SIMPLE ANTHROPOMETRIC PARAMETERS, SOMATOTYPE COMPONENTS, PAI AND TANNER STAGES (UPPER LINE BOYS AND LOWER LINE GIRLS)

	10 vs. 11 yrs	10 vs. 12 yrs	10 vs. 13 yrs	11 vs. 12 yrs	11 vs. 13 yrs	12 vs. 13 yrs
Height	0.986	0.951	0.938	0.972	0.956	0.962
	0.987	0.957	0.912	0.974	0.931	0.978
Weight	0.952	0.905	0.912	0.954	0.940	0.957
	0.966	0.940	0.906	0.966	0.941	0.979
BMI	0.886	0.828	0.847	0.928	0.913	0.943
	0.926	0.814	0.861	0.838	0.915	0.847
Endomorphy	0.851	0.769	0.693	0.863	0.758	0.901
	0.947	0.889	0.894	0.914	0.866	0.890
Mesomorphy	0.810	0.790	0.780	0.867	0.860	0.882
	0.845	0.873	0.829	0.854	0.819	0.912
Ectomorphy	0.885	0.817	0.845	0.922	0.910	0.933
	0.892	0.861	0.970	0.917	0.874	0.943
PAI	0.272	0.381	0.294	0.446	0.352	0.434
	0.581	0.252	0.406	0.495	0.491	0.505
Tanner stage	0.490	0.508	0.314	0.662	0.484	0.683
	0.636	0.365	0.354	0.722	0.607	0.632

p at least <0.05, PAI – physical activity index, BMI – body mass index

5). From the detailed measured anthropometric parameters, the tracking was lowest on the breadth/length values (Table 6).

In boys, the changes in body impedance were significant between four measurement years (Table 7). As a rule, the impedance decreased except between the second and third measurements. In girls, the increase in impedance between the second and third measurement was not pronounced. Both in boys and girls, the impedance index significantly increased every year ($p<0.05$–0.001) (Table 7). The tracking of both body impedance and impedance index was high and decreased slightly with increasing the time interval between the measurements (Table 7).

TABLE 3
INTERPERIOD SPEARMAN CORRELATION COEFFICIENTS OF SKINFOLD THICKNESSES AT FOUR TIMEPOINTS (UPPER LINE BOYS AND LOWER LINE GIRLS)

	10 vs. 11 yrs	10 vs. 12 yrs	10 vs. 13 yrs	11 vs. 12 yrs	11 vs. 13 yrs	12 vs. 13 yrs
Triceps	0.829	0.698	0.646	0.819	0.743	0.842
	0.923	0.848	0.860	0.883	0.815	0.859
Subscapular	0.822	0.760	0.653	0.861	0.747	0.915
	0.950	0.873	0.916	0.910	0.901	0.911
Biceps	0.759	0.633	0.585	0.781	0.709	0.822
	0.852	0.832	0.794	0.893	0.810	0.833
Iliac crest	0.830	0.725	0.592	0.830	0.693	0.884
	0.946	0.892	0.867	0.910	0.844	0.907
Supraspinale	0.789	0.691	0.691	0.782	0.688	0.824
	0.884	0.848	0.858	0.889	0.780	0.816
Abdominal	0.854	0.697	0.591	0.847	0.746	0.878
	0.923	0.912	0.847	0.898	0.852	0.904
Front thigh	0.858	0.771	0.695	0.884	0.712	0.860
	0.897	0.793	0.811	0.906	0.893	0.886
Medial calf	0.850	0.821	0.709	0.844	0.733	0.829
	0.907	0.877	0.817	0.905	0.847	0.878
Mid-axilla	0.848	0.698	0.630	0.815	0.645	0.819
	0.948	0.918	0.878	0.931	0.866	0.931

p at least <0.05

TABLE 4
INTERPERIOD SPEARMAN CORRELATION COEFFICIENTS OF GIRTHS AT FOUR TIME POINTS
(UPPER LINE BOYS AND LOWER LINE GIRLS)

	10 vs. 11 yrs	10 vs. 12 yrs	10 vs. 13 yrs	11 vs. 12 yrs	11 vs. 13 yrs	12 vs. 13 yrs
Head	0.755 0.863	0.846 0.884	0.813 0.847	0.843 0.887	0.796 0.913	0.889 0.883
Neck	0.863 0.908	0.745 0.846	0.804 0.833	0.797 0.904	0.871 0.853	0.791 0.876
Arm relaxed	0.889 0.944	0.877 0.908	0.848 0.878	0.905 0.946	0.866 0.905	0.946 0.952
Arm flexed and tensed	0.921 0.942	0.881 0.899	0.860 0.881	0.933 0.931	0.905 0.901	0.944 0.953
Forearm	0.844 0.944	0.906 0.844	0.889 0.877	0.812 0.878	0.921 0.921	0.949 0.876
Wrist	0.889 0.914	0.849 0.858	0.810 0.870	0.932 0.922	0.893 0.905	0.934 0.941
Chest	0.911 0.950	0.653 0.911	0.896 0.839	0.758 0.951	0.911 0.896	0.683 0.935
Waist	0.923 0.957	0.855 0.885	0.859 0.887	0.879 0.928	0.837 0.914	0.907 0.919
Gluteal	0.954 0.971	0.896 0.822	0.919 0.905	0.883 0.833	0.921 0.922	0.860 0.831
Thigh I	0.924 0.967	0.827 0.909	0.905 0.908	0.838 0.925	0.919 0.925	0.812 0.921
Thigh II	0.918 0.951	0.857 0.813	0.841 0.892	0.889 0.841	0.877 0.916	0.872 0.852
Calf	0.959 0.955	0.788 0.913	0.909 0.906	0.833 0.940	0.935 0.939	0.831 0.949
Ankle	0.926 0.914	0.893 0.855	0.866 0.842	0.931 0.870	0.862 0.850	0.910 0.865

p at least <0.05

TABLE 5
INTERPERIOD SPEARMAN CORRELATION COEFFICIENTS OF LENGTH AT FOUR TIME POINTS
(UPPER LINE BOYS AND LOWER LINE GIRLS)

	10 vs. 11 yrs	10 vs. 12 yrs	10 vs. 13 yrs	11 vs. 12 yrs	11 vs. 13 yrs	12 vs. 13 yrs
Acromiale-radiale	0.961 0.824	0.886 0.819	0.588 0.601	0.934 0.685	0.613 0.570	0.585 0.553
Radiale-stylion	0.875 0.971	0.709 0.910	0.851 0.799	0.836 0.927	0.948 0.798	0.817 0.829
Midstylion-dactylion	0.781 0.432	0.347 0.457	0.595 0.426	0.445 0.844	0.643 0.749	0.552 0.650
Iliospinale box height	0.950 0.968	0.915 0.925	0.923 0.266	0.974 0.967	0.964 0.263	0.958 0.320
Trochanterion	0.947 0.892	0.914 0.815	0.920 0.809	0.940 0.918	0.942 0.900	0.948 0.898
Trochanterion-tibiale-laterale	0.814 0.901	0.801 0.828	0.792 0.477	0.848 0.870	0.823 0.486	0.866 0.515
Tibiale-laterale to floor	0.809 0.842	0.880 0.838	0.852 0.787	0.815 0.865	0.844 0.839	0.900 0.865
Tibiale mediale spy. Tibiale	0.835 0.900	0.734 0.847	0.807 0.754	0.846 0.886	0.935 0.789	0.830 0.807

p at least <0.05

TABLE 6
INTERPERIOD SPEARMAN CORRELATION COEFFICIENTS OF BREADTHS/LENGTHS AT FOUR TIME POINTS (UPPER LINE BOYS AND LOWER LINE GIRLS)

	10 vs. 11 yrs	10 vs. 12 yrs	10 vs. 13 yrs	11 vs. 12 yrs	11 vs. 13 yrs	12 vs. 13 yrs
Biacromial	0.717	0.794	0.860	0.664	0.714	0.791
	0.803	0.815	0.789	0.678	0.622	0.961
Biiliocristal	0.828	0.766	0.707	0.887	0.854	0.923
	0.883	0.758	0.691	0.881	0.776	0.829
Foot length	0.972	0.949	0.798	0.978	0.783	0.803
	0.982	0.924	0.836	0.959	0.868	0.893
Sitting height	0.896	0.813	0.857	0.849	0.848	0.927
	0.961	0.918	0.903	0.945	0.917	0.958
Transverse chest	0.468	0.486	0.376	0.838	0.820	0.821
	0.945	0.899	0.880	0.955	0.929	0.936
A-P chest depth	0.804	0.788	0.700	0.867	0.387	0.897
	0.916	0.869	0.591	0.928	0.561	0.599
Humerus	0.948	0.905	0.909	0.911	0.897	0.911
	0.942	0.868	0.876	0.902	0.890	0.874
Femur	0.968	0.909	0.845	0.929	0.868	0.876
	0.959	0.894	0.879	0.911	0.887	0.929

p at least <0.05

TABLE 7
BODY IMPEDANCE AND IMPEDANCE INDEXES (X±SD) AND INTERPERIOD SPEARMAN CORRELATION COEFFICIENTS IN BOYS AND GIRLS.

	X±SD	Interperiod correlations		
		First measurement (10-year-old)	Second measurement (11-year-old)	Third measurement (12-year-old)
		Boys (n=81)		
Body impedance (Ω)				
First measurement	576.7±57.6			
Second measurement	553.0±64.5	0.904		
Third measurement	557.8±71.0	0.900	0.911	
Fourth measurement	543.2±78.1	0.841	0.877	0.942
Impedance index (height²/resistance)				
First measurement	35.9±5.7			
Second measurement	40.6±7.1	0.926		
Third measurement	45.3±9.4	0.904	0.916	
Fourth measurement	50.0±12.2	0.887	0.871	0.915
		Girls (n=86)		
Body impedance (Ω)				
First measurement	627.9±58.2			
Second measurement	589.1±55.0	0.951		
Third measurement	623.7±68.1	0.874	0.921	
Fourth measurement	608.8±61.5	0.795	0.886	0.914
Impedance index (height²/resistance)				
First measurement	32.5±5.1			
Second measurement	37.5±6.2	0.914		
Third measurement	38.7±6.8	0.864	0.907	
Fourth measurement	42.1±6.6	0.777	0.874	0.900

p at least <0.05

Discussion

The results of the present investigation confirm those of previous studies that during puberty, the changes in anthropometry are very quick and on the other hand there is a significant interindividual variation in the timing and tempo of puberty. The tracking coefficients during four years were, as a rule, high. The results did not confirm our hypothesis that the somatotype components are better predictors of anthropometry than other often used single anthropometric parameters. During puberty, the body impedance decreased and impedance index increased and the tracking was high.

According to Tanner et al.[22], the onset of puberty corresponds to a skeletal age of approximately 11 years in girls and 13 years in boys. The peak height velocity in girls occurs at age 12 with an average height increase of 9 cm/year[19] and in boys approximately 2 years later with a height increase for 10.3 cm/year[20]. In our study, the data about the individual peak height velocities were not available. However, the mean body height increase in boys was highest between 12 and 13 years of age (third and fourth measurement, mean increase 6.9 cm per year) and in girls between 11 and 12 years of age (second and third measurement, mean increase 6.3 cm). One of the weaknesses of the study is probably the fact that we did not measure the children for at least one more year, at least the boys. However, the additional measurement was impossible because several children changed schools.

Previous investigations confirm that in boys, the peak weight velocity is at about the age of 14 and at an average of 9 kg/year. In girls, the peak weight gain lies behind peak height velocity by approximately 6 months and reaches 8.3 kg/year at the age of about 12.5 years[23,24]. In our study, the mean peak increase in body weight in boys and girls was between 11 and 12 years of age, 5.7 and 5.2 kg, respectively (see Table 1). At that time the tracking correlations were also very high (r=0.954 in boys; r= 0.966 in girls).

A previous study has indicated that the relationship between adult and childhood skinfold ratio measurements is weak in boys and slightly better in girls[25]. In our study, during puberty, the development of skinfold thicknesses is different between trunk and extremities and there are sex-specific differences. Similarly to Tanner and Whitehouse[26] cross-sectional study, the skinfold thicknesses on the extremities decreased and trunk thickness continued to increase with increasing age in our investigation. However, in girls, both arm and trunk skinfold thicknesses increased. Probably, the decline in skinfold thicknesses in boys reflects the regional growth of the fat-free mass.

Carter et al.[11] emphasized that in studies of children and adolescent growth, the measurement of somatotype is particularly important because it recognizes that individual somatotypes change over time. In our study, during puberty, endomorphy increased especially rapidly in boys at the beginning of puberty (see Table 1). However, compared with other somatotype components, the tracking coefficients were relatively low (see Table 2). This increase is connected with the increase of most of the skinfold thicknesses. This finding is in agreement with other studies[9]. Mesomorphy was stable during puberty in boys and decreased in girls (see Table 1). With increasing of the time interval, the tracking coefficients decreased rapidly (see Table 2). We agree with the results of several cross-sectional studies that the changes in somatotype components are sometimes contradictory[22] and also depend on sex[10,27].

Several BIA equations have been presented for calculating different body composition parameters in children[28,29]. However, all the equations are very group-specific and developed cross-sectionally against reference measures. Secondly, body composition is subject to very rapid changes during puberty, and this may explain why there is no longer a clear difference between the methods in that period. Accordingly, it is probably better to use only body impedance and calculated impedance index. However, the disadvantages of BIA measurements include the insensitivity of the method for detecting small changes in body composition in individuals followed over time, dependency of the estimates on the relative amounts of extra- and intracellular water, and the potential distortion of values due to body configuration, as in abdominal obesity[30]. In our study, as a rule, the impedance decreased every year. It is well known that the hydration level of the fat-free body is higher in prepubertal children than at later ages and especially in boys fat decreased at the end of puberty. In contrast, impedance index increased with age, which is in accordance with other investigations[31].

In conclusion, our results indicate that during puberty, the detailed anthropometric parameters and body impedance tracked highly. However, the tracking of PAI and Tanner stages was significant but relatively low.

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PRAĆENJE ANTROPOMETRIJSKIH PARAMETARA I BIOELEKTRIČNE IMPEDANCIJE KOD DJEČAKA I DJEVOJAKA U PUBERTETU

S A Ž E T A K

Cilj ove studije bio je istražiti antropometrijske parametre i tjelesnu impedanciju estonske djece u pubertetu. Mjerenja su provođena jednom godišnje kroz period od četri godine. Ukupno su istraženi 81 dječak i 86 djevojaka, koji su na početku studije bili u dobi od 10–11 godina. Pubertetski status mjeren je fazama seksualnog dozrijevanja prema Tanner-u[18] i indeksom tjelesnih aktivnosti (PAI) prema Telami i dr.[17]. Mjerene su visina i težina te je izračunavat BMI. Ukupno je izmjereno 9 kožnih nabora, 13 opsega, 8 dužina i 8 širina/dužina prema protokolu internacionalnog društva za naprednu kinantropometriju. Komponente somatotipa procjenjivane su metodom prema Carter i Heath[9]. Tjelesna impedancija mjerena je uređajem »Multiscan 500« (Bodystat, UK) te je izračunavat indeks impedancije (visina^2/impedancija). Korelacija tjelesne visine, težine, BMI, kožnih nabora, opsega, dužina, širina/dužina i tjelesne impedancije je bila viska (kao pravilo $r \geq 0.9$), a kroz duži period, korelacije su se smanjivale. Korelacije između određivanih parametara prema PAI i Tanner-u bile su značajne, ali prilično niske. Povečanje tjelesne visine bilo je najvišeu u dobi od 12–13 godina kod dječaka (6.9 cm po godini) te u dobi od 11–12 godina kod djevojaka (6.3 cm po godini). Respektabilno mršavljenje javlja se kod dječaka i djevojaka u dobi od 11–12 godina, 5.7 kg odnosno 5.,2 kg. Sa godinama tjelesna impedancija se smanjuje, a indeks impedancije raste. U zaključku možemo kazati da su određivani detaljni antropometrijski parametri i tjelasna impedancija tijekom puberteta bili visoki. Određivanje PAI i Tanner stadija bilo je značajno ali relativno nisko.