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Bivariate body height-weight classification – a useful tool in systematization and analysis of medical data

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Background. An anthropometric whole body model used in different Estonian studies of Kaarma and her co-workers since 1995 has proved to work in assessment of physical peculiarities of the body and its structure regularities in different age groups in both genders. Besides systematization of different body measurements, different authors suggested to use this classification in various applied studies, including medicine.

Material and methods. The potential of using body height-weight standard deviation (SD) classification is shown through the example of adolescents (734 students: 352 boys and 382 girls) aged 12–15, who where studied in respect of their sexual maturation (according to suggestions of Tanner) as well as systolic and diastolic blood pressure (BP) (measured with mercury sphygmomanometer on the subject's right arm in a sitting position). Anthropometric variables were measured according to the protocol recommended by the International Society for Advancement of Kinanthropometry (21). All the subjects were assigned into three height / weight-concordant and two height/weight-discordant categories according to the suggestions of Kaarma (11).

Results. 1. Differences of the mean maturation signs and mean systolic and diastolic BP values between height-weight categories (HW-categories) were statistically significant for both boys and girls ($p < 0.001$). 2. In the same age group the mean of the signs studied increased from category I (*small*) to III (*large*), and discordant categories (*pyknomorphous* and *leptomorphous*) yielded the large category. 3. Sexual development of *leptomorphous* boys tend to be advanced in comparison with *pyknomorphous* boys, in girls it was *vice versa*: *pyknomorphous* were advanced compared to *leptomorphous* girls, though this difference was not statistically significant among all the sexual maturation signs. 4. The highest arterial blood pressure values were in the *large* category of both boys and girls. 5. Boys had elevated blood pressure values more often than girls of the same age group. Results of our study suggested monitoring adolescents of some height-weight categories more carefully, including children of height-weight discordant categories.

Conclusion. The use of height-weight SD classification allows finding out whether the differences in the variables studied are related to the body build as a whole or not.

Key words: body height-weight SD classification, adolescent, sexual maturation, blood pressure

INTRODUCTION

In medical practise it is not always easy to find statistically significant relations between several studied parameters. The reasons for this could be different: the distinguished groups of patients are not big enough, there is a great variability in parameters in different persons, all parameters are not fixed in all the subjects, differences in body build could influence the relations etc. This makes distinguishing the border between norm and disorder for a concrete person more difficult. For example, relations between the physique and sexual maturation are not clear, and the data concerning this relationship are relatively scarce and controversial, especially about boys (1–4). Although it is well-known that BMI and body fat content correlate positively with blood pressure (6, 7), the relations between blood pressure values and body build are not so clear (8, 9) and are not well investigated as is the case with children.

Until now for the description of characteristics of the human body as a whole there are 3 main approaches based on the external body form: 1. Heath-Carter somatotyping (2, 4), derived from original Sheldon concepts (10); 2. method of multivariate statistical technique: factor analysis (principal component analysis), discriminant analysis etc.; 3. a whole body model based on a bivariate body height-weight SD classification (11–13). Several Estonian studies (14–19) have used the last classification, and this classification proved to be useful in the assessment of physi-

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cal peculiarities of the body and its structure regularities. Taking into consideration different samples Estonian research (12–19) has showed that in the all age groups height and weight showed a gradual increase in height-weight categories I–III (from categories *small* to *large*). This was accompanied by a statistically significant increase in length, breadth and depth measurements, some of the limb thicknesses, circumferences, body mass index and body fat content (11, 12). Categories IV and V of all age groups (Fig. 1) have also revealed several characteristic differences between pyknic (or pyknomorpmous) and leptosomic (leptomorphous) persons. In pyknics, the breadth and depth measurements and trunk and limb circumferences and small bone breadths (the breadth of femur and humerus), body mass index and indications of body fat content were significantly greater. The limbs were significantly longer and body density greater in the leptosomes.

This Estonian system of sport- and constitution typology, as Raschka (20) named HW-classification, has been suggested by different research (14, 15, 20) as a possibility for systematising the characteristics of the human body as a whole in order to carry out physiological, psychological, nutritional, sociological and sport studies. We were interested in its usage concerning the date of adolescent sexual maturation and blood pressure.

MATERIAL AND METHODS

Study subjects. A cross-sectional sample consisting of 734 students (352 boys and 382 girls) randomly selected from different schools of Tartu, Estonia, was studied in 1997–1999. All the subjects were in the age range from 12 to 15 years, Estonians in origin. The parents or guardians of children and children themselves gave their oral permission for voluntary testing. The study was approved by the Medical Ethics Committee of the University of Tartu, Estonia.

Methods. Measurements were performed in the morning at schools with subjects' bladder emptied. Children did not exercise before testing. Anthropometric measurements were made according to the protocol recommended by the International Society for Advancement of Kinanthropometry (21). Stature was measured using a Martin metal anthropometer in cm (±0.1), and body mass was measured with medical scales in kg (±0.05 kg). The mean of at least two trials was used in the analysis.

Blood pressure measurements were obtained on the subjects' right arm in relaxed, sitting position using a standard mercury sphygmomanometer. The mean of two trials was used in the analysis. The blood pressure value was measured in 728 children (357 boys and 371 girls).

Assessment of height-weight categories. In all age groups both body height and mass values were divided into 3 SD-classes (Fig. 1). The medium class is situated between –0.5 SD and 0.5 SD with respect to the age group mean (M ± 0.5 SD), the other classes contain the respective outer values. All the subjects were assigned into one of the following five categories with three height/weight-concordant categories: I – *small* (small height – small weight), II – *medium* (medium height – medium weight), III – *large* (big height – big weight); and two height/weight-discordant categories: IV – the so-called *pyknomorphous*, and V – the so-called *leptomorphous* one. Thus, categories IV and V contained three height/weight subclasses each, as shown in Fig. 1.

Assessment of sexual maturation. Pubertal status of the subjects was assessed according to the descriptions of stages given by Tanner (22, 23). Self-assessment as a suitable method suggested by previous research (24–26) was used for the evaluation of pubic hair (PH1, PH2+, PH3+, PH4+, PH5+) and axillary hair (AX1, AX2+, AX3+, AX4+, AX5+) development stage in both genders, and breast development (MA1, MA2+, MA3+, MA4+, MA5+) stages in girls. Each subject was asked to observe photographs (27, 28) of the stages of secondary sex characteristics and also to read the descriptions of stages. The subjects were asked to view the photographs and to read the descriptions of stages very carefully and to make a decision about which stage reflected their current status most. In our study, correlations of r = 0.71–0.83 were obtained between ratings on two occasions (7 days' interval) in a subsample of 29 boys and 24 girls. As a number of teenagers did not answer all the questions about their sexual development, the number of subjects in different cases can slightly vary. In these cases the different number of persons was shown in the results.

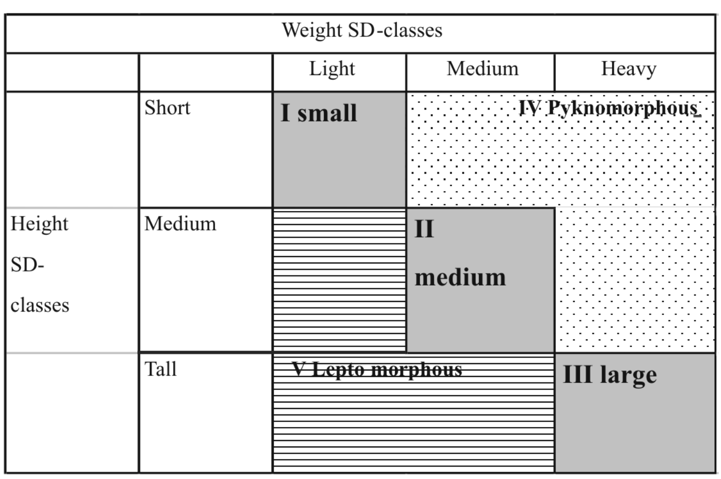

Fig. 1. The height-weight SD classification

Statistical analysis. Standard statistical methods of SAS statistical package were used to calculate mean (M) and standard deviation (SD), median (Med) and coefficient of variation (CV) of parameters and percentages.

Statistical comparisons of height-weight SD-classes were made using two-way ANOVAs. Scheffe's and Tukey's tests as the posteriori tests were applied to study which group means were significantly different ($p \leq 0.05$).

Correlation analysis was performed to establish significant relationships ($p < 0.0001$ and $p < 0.05$) between the variables studied.

RESULTS

The variability of sexual maturation signs by age groups (Tables 1, 2) was very high in both genders. There were quite big differences in mean maturation signs of boys and girls of different height-weight categories also (Tables 3, 4). As could be expected, with an increase in age a gradual increase of mean maturation signs appeared within all HW-categories. Mean genital sizes increased gradually from height-weight categories I to III (*small-medium-large*) in boys aged from 12 to 15

Table 1. **Sexual development stages in different age groups of boys**

Age (years)	n	Pubic hair stages in boys					
		M	SD	Med	Min	Max	CV
12	64	1.80	0.69	2	1	4	38.63
13	96	2.29	0.83	2	1	4	36.32
14	100	2.99	0.94	3	1	5	31.35
15	92	3.66	0.68	4	1	5	18.67
Total	352						
Age (years)	**n**	**Axillare hair stages in boys**					
		M	**SD**	**Med**	**Min**	**Max**	**CV**
12	64	1.40	0.58	1	1	3	41.75
13	96	1.63	0.78	1	1	4	48.29
14	99	2.11	0.94	2	1	5	44.32
15	92	2.66	1.02	3	1	5	38.28
Total	351						
Age (years)	**n**	**Genital size (ml) in boys**					
		M	**SD**	**Med**	**Min**	**Max**	**CV**
12	65	6.78	3.56	6	2	20	52.53
13	98	7.64	3.80	8	2	20	49.68
14	93	10.14	5.22	10	2	25	51.44
15	92	12.30	4.36	12	4	25	35.45
Total	**348**						

Table 2. **Sexual development stages in different age groups of girls**

Age (years)	n	Mammillare stages in girls					
		M	SD	Med	Min	Max	CV
12	72	2.49	0.77	3	1	4	30.93
13	110	2.93	0.75	3	1	5	25.64
14	104	3.40	0.78	3	1	5	22.98
15	96	3.79	0.66	4	2	5	17.50
Total	382						
Age (years)	**n**	**Pubic hair stages in girls**					
		M	**SD**	**Med**	**Min**	**Max**	**CV**
12	72	2.46	0.99	2	1	4	40.35
13	110	2.86	0.94	3	1	5	32.92
14	104	3.44	0.89	4	1	5	25.87
15	96	3.97	0.72	4	1	5	18.08
Total	382						
Age (years)	**n**	**Axillare hair stages in girls**					
		M	**SD**	**Med**	**Min**	**Max**	**CV**
12	72	1.89	0.94	2	1	4	49.91
13	110	2.14	0.97	2	1	5	45.49
14	102	2.80	0.88	3	1	5	31.36
15	96	3.29	0.88	3	1	5	26.78
Total	380						

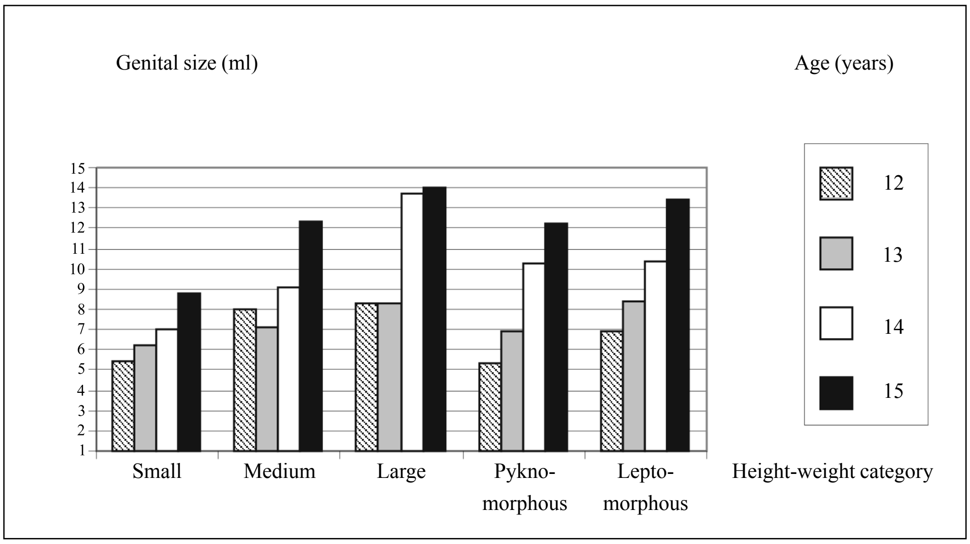

Fig. 2. Genital size (ml) in boys of different height-weight categories

Table 3. **Sexual maturation by different height-weight SD-categories (HW-category) of boys**

HW-category	**I – small (n = 77)**				**II – medium (n = 86)**				**III – large (n = 51)**			
Age	**12 yrs**	**13 yrs**	**14 yrs**	**15 yrs**	**12 yrs**	**13 yrs**	**14 yrs**	**15 yrs**	**12 yrs**	**13 yrs**	**14 yrs**	**15 yrs**
Variable	n = 14	n = 22	n = 25	n = 16	n = 13	n = 24	n = 28	n = 21	n = 10	n = 12	n = 12	n = 17
PH mean	1.57	2.00	2.20	3.19*′	1.77	2.08	3.26*′	3.52*	2.10	3.09*′	3.50*	4.00*
±SD	0.65	0.76	0.87	0.75	0.60	0.65	0.81	0.87	0.88	0.90	0.78	0.61
(min…max)	1…3	1…3	1…4	2…4	1…3	1…3	2…5	1…5	1…4	1…4	2…5	3…5
GEN mean (ml)	5.43	6.23	7.05	8.82*	8.00	7.08	9.05	12.38*′	8.30	8.33	13.71	14.06*
±SD	2.41	2.89	4.05	3.50	3.88	3.84	4.13	3.09	5.64	3.03	5.89	0.84
(min…max)	2…10	2…12	2…15	4…15	4…15	3…20	3…15	6…20	2…20	4…12	2…25	6…20
AX mean	1.29	1.32	1.52	1.75	1.39	1.79	2.36*	2.71*	1.40	2.08	2.67*	3.12*
±SD	0.45	0.57	0.71	0.78	0.65	0.78	0.90	0.90	0.70	1.08	0.64	0.86
(min…max)	1…2	1…3	1…3	1…3	1…3	1…3	1…4	1…4	1…3	1…4	2…4	1…4
HW-category	**IV – pyknomorphous (n = 47)**				**V – leptomorphous (n = 82)**							
Age	**12 yrs**	**13 yrs**	**14 yrs**	**15 yrs**	**12 yrs**	**13 yrs**	**14 yrs**	**15 yrs**				
Variable	n = 11	n = 13	n = 13	n = 10	n = 16	n = 25	n = 15	n = 26				
PH mean	1.46	2.23*′	2.77*	3.75*′	2.06	2.40	3.27*′	3.81*				
±SD	0.69	0.60	0.60	0.45	0.57	0.91	0.88	0.40				
(min…max)	1…3	2…4	2…4	3…4	1…3	1…4	2…5	3…4				
GEN mean (ml)	5.30	8.92	10.31*	12.25*	6.88	8.42	10.39	13.46*				
±SD	3.16	4.43	2.98	4.43	2.15	4.19	5.55	4.88				
(min…max)	2…12	3…15	5…15	6…20	4…10	2…20	4...25	5…20				
AX mean	1.45	1.46	2.00	2.83*′	1.44	1.60	1.93	2.81*′				
±SD	0.52	0.52	0.82	0.94	0.63	0.82	1.22	1.10				
(min…max)	1…2	1…2	1…3	1…5	1…3	1…4	1…5	1…5				

* – statistically significant ($p < 0.05$) difference with age 12.

′ – statistically significant ($p < 0.05$) difference with previous age group.

(Table 3), though individual variability of this sign was very great. *Leptomorphous* boys tend to be advanced in their genital size in comparison with *pyknomorphous* boys (Fig. 2). At the age of 12–15 there were also differences in mean PH (pubic hair development according to Tanner) of boys who belong to three different height/weight-concordant categories (I–III) (*small-medium-large*) (Fig. 3). PH means of the height/weight-discordant categories were different: *leptomorphous* boys aged 12–15 were advanced in their PH status in comparison with *pyknomorphous* boys, though this difference was not significant at the age of 15.

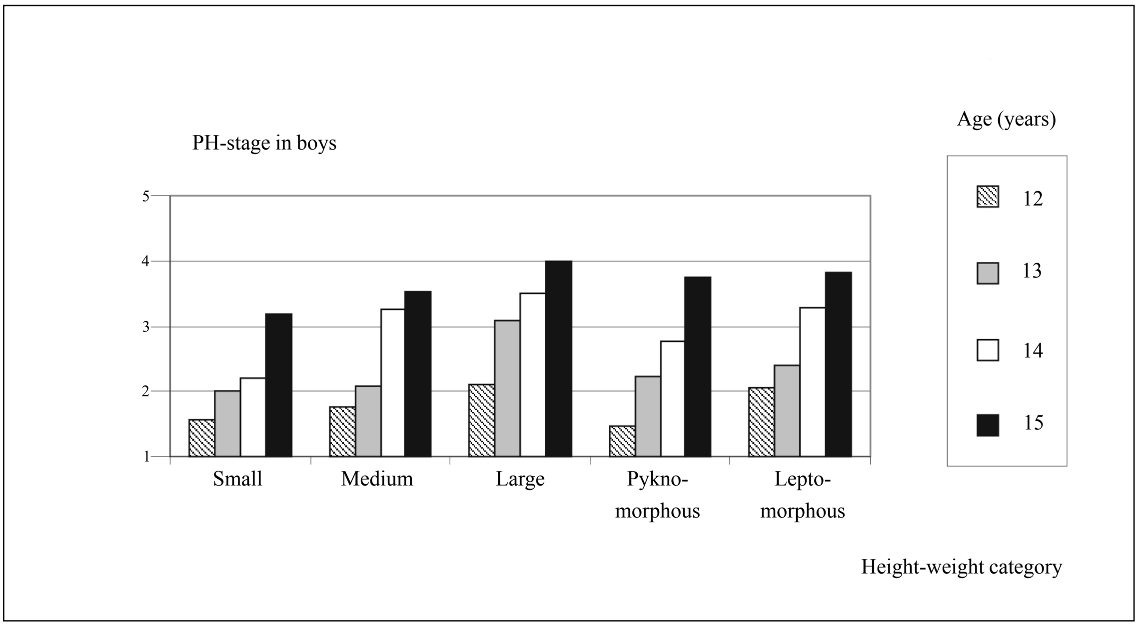

Fig. 3. Pubic hair (PH) stage in boys of different height-weight categories

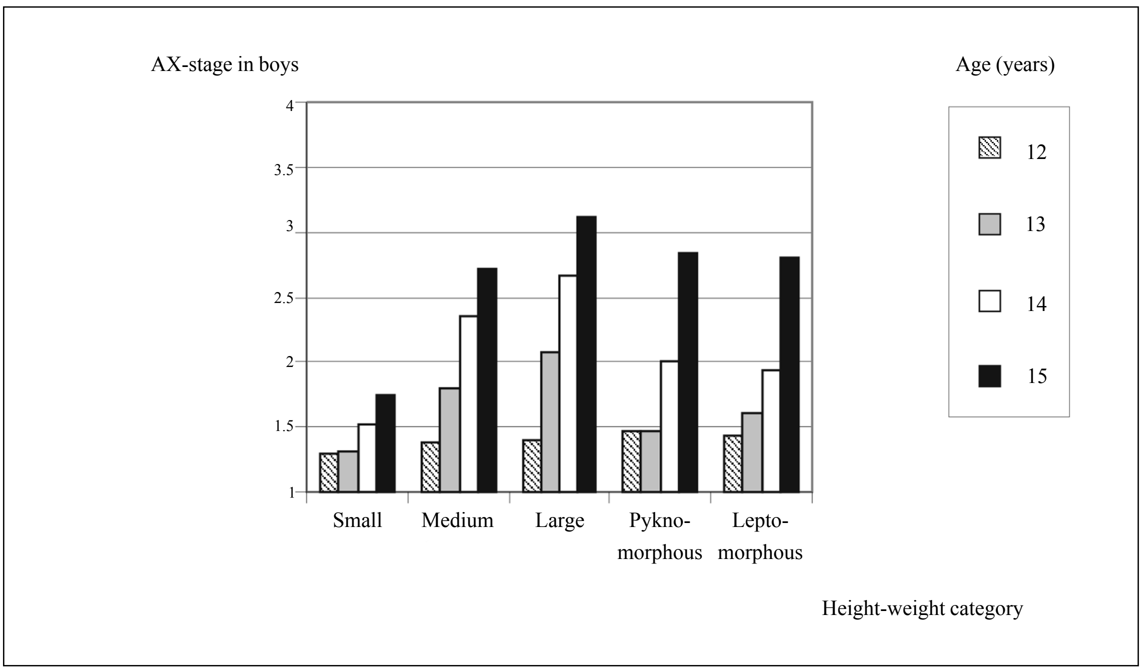

Fig. 4. Axillare hair (AX) stage in boys of different height-weight categories

Differences in AX hair development of *pyknomorphous* and *leptomorphous* boys were not significant (Fig. 4). In our study the outliers of sexual development were *pyknomorphous* and *small* boys, though they were normal boys, just with their particular body build and with their development peculiarities.

In girls individual variability of sexual maturation signs is not as big as in boys but following the same pattern: mean mammillare stage (breast stage) increased also from height-weight categories I to III (*small-medium-large*), and discordant categories, from the *large* category (Table 4). Among the girls, the *pyknomorphous* were advanced in comparison with *leptomorphous* girls in their sexual development signs (Figs. 5–7), except in PH stages (Table 4).

Mean blood pressure readings increased with age in both sexes (Tables 5, 6). The SBP and especially DBP showed great variability within the age groups (Tables 5, 6). No significant gender differences were found in mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) values.

The influence of age on blood pressure (SBP and DBP) was not strong (r = 0.26–0.33), though significant. The height-weight SD-category was weakly (r = 0.13–0.21), though also significantly associated with SDP and DBP in both genders.

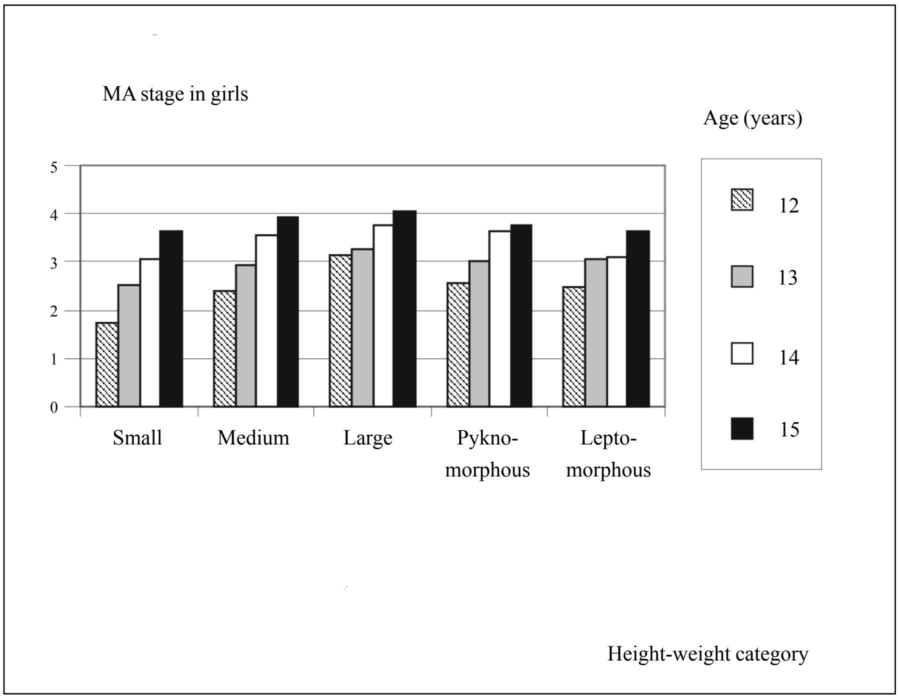

Fig. 5. Mammilare (MA) stage in girls of different height-weight categories

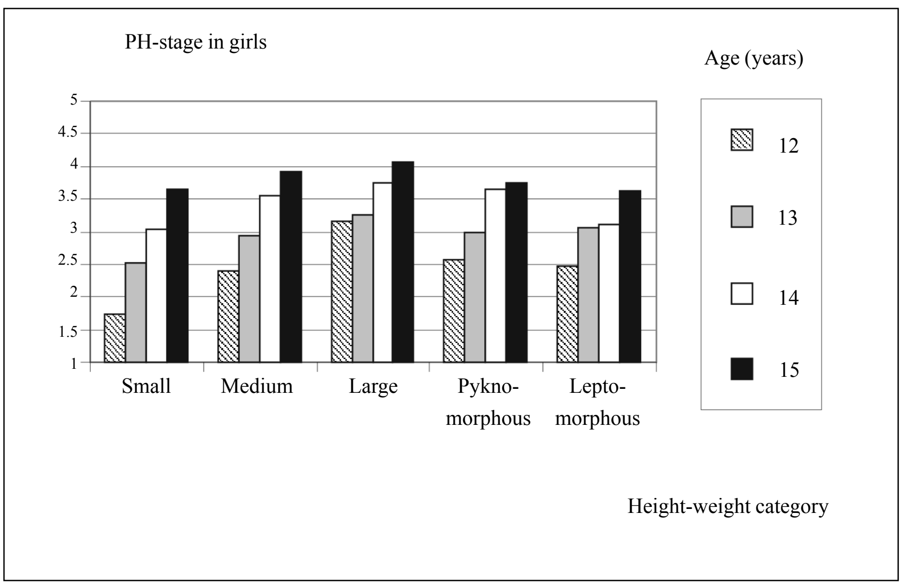

Fig. 6. Pubic hair (PH) stage in girls of different height-weight categories

Correlation coefficients between body height and weight and SBP and DBP were up to medium ($r = 0.34–0.51$ and $0.39–0.57$, respectively), weaker in girls. Correlation analysis for boys and girls together showed no relations between gender and SBP, DBP ($r = -0.01$ and $r = 0.06$, respectively).

The mean and median values of SBP and DBP obtained for five HW-categories in the studied age groups are presented in Tables 7, 8. The highest arterial blood pressure values were in boys of large category and in boys with height-weight discordant body build (pyknomorphous and leptomorphous boys) (Tables 7, 8). Differences in SBP and DBP between HW-categories were statistically significant for both genders ($p < 0.001$) (Fig. 8).

In boys, Scheffe's test showed statistically significant differences in SBP of boys among all the HW-categories except between discordant body-build categories (HW-category IV and V) as well as between HW-category II and IV, also between II and V. According to Scheffe's and Tukey's tests, statistically significant ($p < 0.001$) SBP differences in girls and DBP differences in boys were only between HW-categories small and large, as well as between medium and large categories. At the same time, different HW-categories were not distinct by their mean age. Differences between categories IV and V in SBP and DBP were statistically significant only for boys aged 15.

Table 4. **Sexual maturation by different height-weight SD-categories (HW-category) of girls**

HW-category	I – small (n = 82)				II – medium (n = 81)				III – large (n = 74)			
Age	12 yrs	13 yrs	14 yrs	15 yrs	12 yrs	13 yrs	14 yrs	15 yrs	12 yrs	13 yrs	14 yrs	15 yrs
Variable	n = 15	n = 27	n = 23	n = 17	n = 14	n = 27	n = 22	n = 15	n = 19	n = 19	n = 19	n = 16
MA mean	1.73	2.52*′	3.04*	3.65*	2.50	2.93*′	3.55*	3.93*	3.11	3.26	3.74*	4.06*
±SD	0.88	0.70	0.71	0.79	0.52	0.62	0.67	0.59	0.32	0.81	0.65	0.68
(min…max)	1…4	1…4	2…5	2…5	1…3	2…4	2…5	3…5	3...4	2…5	3…5	3…5
PH mean	1.40	2.11*′	2.91*′	4.00*′	2.71	3.07*′	3.64*′	3.73*′	3.16	3.37	3.79	4.13*
±SD	0.51	0.64	0.90	0.71	0.72	0.78	0.90	1.03	0.76	1.07	0.92	0.62
(min…max)	1…2	1…3	1…4	2…5	1…4	1…4	2…5	1…5	1…4	1…5	1…5	3…5
AX mean	1.40	1.78	2.52*′	2.88*	1.93	2.11	2.96*′	3.40*	2.63	2.74	3.11	3.63*
±SD	0.63	0.93	0.79	1.17	0.92	0.97	0.90	0.74	0.96	0.99	0.83	0.62
(min…max)	1…3	1…4	1…4	1…5	1…3	1…5	1…4	2…5	1…4	1…4	1…4	3…5

HW-category	IV – pyknomorphous (n = 58)				V – leptomorphous (n = 87)			
Age	12 yrs	13 yrs	14 yrs	15 yrs	12 yrs	13 yrs	14 yrs	15 yrs
Variable	n = 7	n = 10	n = 20	n = 21	n = 16	n = 27	n = 20	n = 24
MA mean	2.57	3.00	3.65*	3.76*	2.44	3.07	3.10	3.63*
±SD	0.53	0.82	0.88	0.54	0.73	0.73	0.79	0.65
(min…max)	2…3	2…4	2…5	3…5	1…4	1…4	1…4	2…4
PH mean	2.14	2.60	3.65*′	3.90*′	2.65	3.15	3.30	3.96*
±SD	0.69	0.70	0.59	0.62	1.09	0.91	0.86	0.62
(min…max)	1…3	2…4	2…4	3…5	1…4	1…5	1…4	2…5
AX mean	1.71	2.00	2.68	3.38*	1.56	2.15	2.80*	3.17*
±SD	0.95	0.94	0.82	0.92	0.73	0.86	1.00	0.82
(min…max)	1…3	1…4	1…4	1…5	1…3	1…4	1…5	1…4

* – statistically significant ($p < 0.05$) difference at the age of 12.

′ – statistically significant ($p < 0.05$) difference with previous age group.

Table 5. **Systolic blood pressure (BP) in different age groups of boys and girls**

Age (years)	n	Systolic BP (mm Hg) in boys					
		M	SD	Med	Min	Max	CV
12	66	102.39	9.36	103	80	120	9.14
13	98	106.82	11.93	104	87	140	11.17
14	101	108.00	10.86	108	80	135	10.05
15	92	113.98	10.23	112	94	150	8.97
Total	357						
Age (years)	**n**	**Systolic BP (mm Hg) in girls**					
		M	**SD**	**Med**	**Min**	**Max**	**CV**
12	79	101.90	10.17	100	80	126	9.99
13	109	108.54	11.24	108	84	150	10.36
14	91	108.00	12.32	106	80	150	11.41
15	92	112.12	10.68	110	90	141	9.53
Total	371						

In the studied age range the mean SBP of category I boys (mean age 13.58) did not reach the mean of 12-year-old boys. Mean SBP of large boys (mean age 13.95) and large girls (mean age 13.56) exceeded the mean SBP of 15-year-olds.

The main part of boys and girls with elevated BP belonged to the large HW-category, and part of boys, to the class of discordant body build (HW-categories IV and V) (Table 9). The percentage of *leptomorphous* boys with higher DBP values was even higher than that of *pyknomorphous* boys. The higher SBP and DBP values were in large category girls followed by *pyknomorphous* girls.

Table 6. **Diastolic blood pressure (BP) in different age groups of boys and girls**

Age (years)	n	Diastolic BP (mm Hg) in boys					
		M	SD	Med	Min	Max	CV
12	66	58.48	8.01	58	40	80	13.70
13	98	62.11	8.88	60	45	95	14.30
14	101	63.34	8.76	60	48	86	13.84
15	92	66.77	8.37	68	50	90	12.54
Total	357						
Age (years)	**n**	**Diastolic BP (mm Hg) in girls**					
		M	**SD**	**Med**	**Min**	**Max**	**CV**
12	79	60.08	8.58	60	40	80	14.29
13	109	64.28	9.32	62	42	90	14.50
14	91	65.22	8.36	64	40	90	12.82
15	92	66.08	6.94	66	50	87	10.51
Total	371						

Table 7. **Systolic blood pressure (BP) by height-weight SD-categories (HW-category) in 12–15-year-old boys and girls**

HW-category	%	Systolic BP (mmHg) in boys					
		M	SD	Med	Min	Max	CV
I – small	22.13	100.63	9.62	100	80	124	9.56
II – medium	22.97	108.45	9.84	110	80	132	9.08
III – large	17.65	115.97	9.17	116	93	150	7.90
IV –pyknomorphous	14.01	109.88	10.32	110	92	135	9.41
V – leptomorphous	23.25	108.16	12.25	108	80	140	11.33
Total	100.0						
HW-category	**%**	**Systolic BP (mmHg) in girls**					
		M	**SD**	**Med**	**Min**	**Max**	**CV**
I – small	21.05	104.08	11.05	103.5	80	145	10.61
II – medium	21.05	106.92	12.50	104.0	82	150	11.69
III – large	19.39	112.03	13.07	110	80	150	11.68
IV – pyknomorphous	15.24	110.49	9.18	108	92	130	8.31
V – leptomorphous	23.27	108.17	10.32	108	88	140	9.53
Total	100.0						

Table 8. **Diastolic blood pressure (BP) by height-weight SD-categories (HW-category) in 12–15-year-old boys and girls**

HW-category of boys	%	Diastolic BP (mmHg)					
		M	SD	Med	Min	Max	CV
I – small	22.13	58.96	6.53	58	40	72	11.07
II – medium	22.97	62.31	8.06	60	48	80	12.93
III – large	17.65	68.05	8.52	70	52	90	12.52
IV –pyknomorphous	14.01	63.86	8.44	62	48	80	13.21
V – leptomorphous	23.25	63.13	10.53	60	45	95	16.67
Total	100.0						
HW-category of girls	**%**	**Diastolic BP (mmHg)**					
		M	**SD**	**Med**	**Min**	**Max**	**CV**
I – small	21.05	61.64	8.77	60	40	90	14.23
II – medium	21.05	62.57	8.70	62	40	80	13.91
III – large	19.39	67.87	8.52	68	48	90	12.55
IV – pyknomorphous	15.24	65.51	7.70	64	44	85	11.76
V – leptomorphous	23.27	64.27	7.09	64	42	80	11.03
Total	100.0						

Table 9. **Elevated systolic blood pressure (SBP) among different height-weight SD-categories (HW-category) of boys and girls**

HW-category of boys	SBP above 120 mmHg		SBP above 130 mmHg		DBP above 75 mmHg		DBP above 80 mmHg	
	n	%	n	%	n	%	n	%
I – small	1	1.3	0	0	0	0	0	0
II – medium	8	9.8	1	1.2	6	7.3	0	0
III – large	17	**27.0**	2	3.2	12	**19.1**	2	3.2
IV – pyknomorphous	9	18.0	2	4.0	6	12.0	0	0
V – leptomorphous	11	13.3	4	4.8	13	15.7	3	**3.6**
Total	46	12.9	9	2.5	37	10.4	5	1.4
HW-category of girls	**SBP above 120 mmHg**		**SBP above 130 mmHg**		**DBP above 75 mmHg**		**DBP above 80 mmHg**	
	n	%	n	%	n	%	n	%
I – small	2	2.6	1	1.3	3	4.0	1	1.3
II – medium	9	11.8	3	3.9	5	6.6	0	0
III – large	15	**21.4**	6	8.6	14	**20.0**	2	2.9
IV – pyknomorphous	7	12.7	0	0	7	12.7	2	**3.6**
V – leptomorphous	8	9.52	2	2.4	3	3.6	0	0
Total	41	11.4	12	3.3	32	8.9	5	1.4

DISCUSSION

Variations of normal puberty are so great that may mimic pathologic puberty. The assessment of persons against their body parameters as a hole could be helpful in distinguishing the constitutional trends in the studied parameters. It has been suggested that differences in the body build (dominant somatotype) could be associated not only with differences at the beginning of maturation, but also with differences in maturation rate: dominance of ectomorphy is connected with late but fast maturation, mesomorphy with early but average rate maturation and endomorphy with early but prolonged maturation (1). Though some studies (29) could not find any differences in maturation stages of different somatotypes of boys, our data indicated that it was reasonable to study sexual maturity parameters against the background of body parameters as a whole. Our data suggested that genital size, PH and AX hair stage differences were related to the body physique differences in boys. Mean genital sizes increased from HW-categories I–III, as did PH and AX hair development stages. The mean genital size of *small* category as well as discordant categories (*leptomorphous* and *pyknomorphous*) tended to be inferior in comparison with *medium* and *large* categories. *Leptomorphous* boys were advanced by their PH and genital size in comparison with *pyknomorphous* boys. In girls our data are generally in concordance with the investigations that showed higher endomorphy component or relative fatness of physique to be connected with earlier sexual maturity (3, 5, 29), as in our study *pyknomorphous* girls tended to be more advanced in comparison with *leptomorphous* girls (Table 4), though statistically significantly not in all the variables and not in all age groups. Indirectly our cross-sectional data pointed out that HW-categories could be different in their maturity rates if we followed the data by ages. We can also see that height-weight disconcordance could be related to the differences in sexual development. For example, all the girls who did not reach the final breast stage at the age of 15 belonged to the *leptomorphous* category. Girls aged 12–15 with breast stage 1 belonged only to *small* and *leptomorphous* categories (Table 4).

Our results are in concordance with the data of Järvelaid et al. (14) who analyzed the results of HW-categories by age at menarche in 15–18-year-old girls and demonstrated that the study subjects with menarche before the age of 12 belonged to the non-corresponding HW-category IV. Pre-menarcheal girls aged 15–18 belonged to *smalls* (70%) and *leptosomes* (30%), so they all had relatively small weight and small, medium or big height (14).

Our results indicated that the small size and belonging to the HW discordant category could be related to the differences in sexual development. The distribution of the data by HW-categories helped to see tendencies along with changes in body parameters and ages even when the data were cross-sectional and not very numerous.

This study also examines whether the body build could be related to the elevated BP in children. Previous studies of children and adolescents (30, 31) did not point out any somatotype that could be related with higher CVD risk factors or elevated BP values. Some authors have pointed out that body composition is related to BP levels (6). The positive relation between fat content of the body and blood pressure is well known (7), also in case of children (32–34).

We used a height-weight classification (11–13) based on a bivariate model to analyse whether BP is related to body size differences or whether the body quantity and BP are related.

Other investigations (35, 36) have shown that blood pressure values of teenagers were slightly higher in boys than in girls. In our study this difference was not significant, as in the study by Suurorg and Tur (37). Correlation analysis suggested that influence of HW-category on BP is not strong ($r = 0.13–0.21$), although significant ($p < 0.05$), and for SBP of boys even highly significant ($p < 0.0001$).

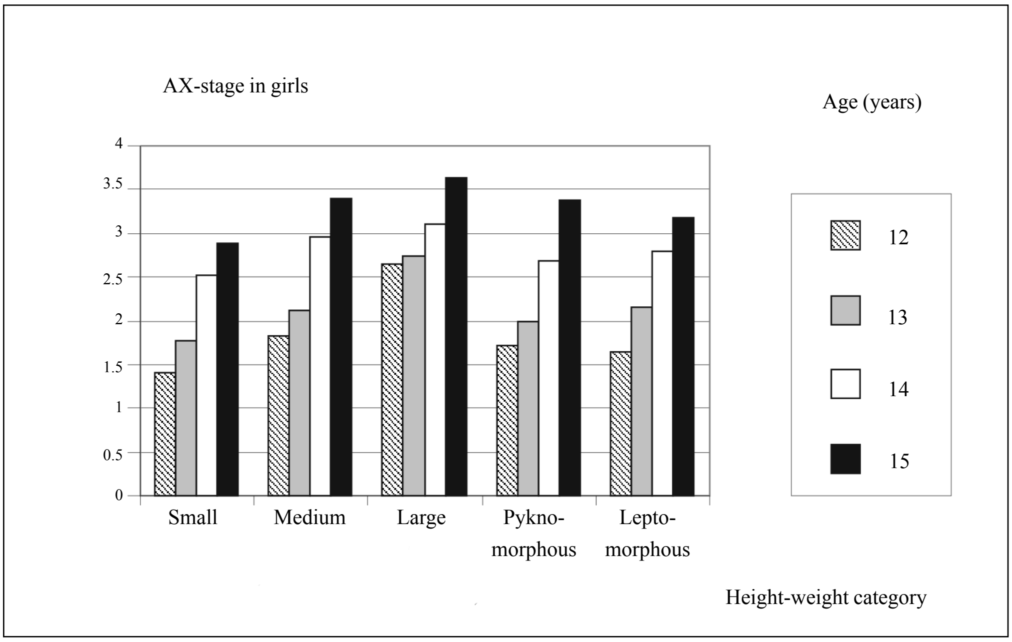

Fig. 7. Axillare hair (AX) stage in girls of different height-weight categories

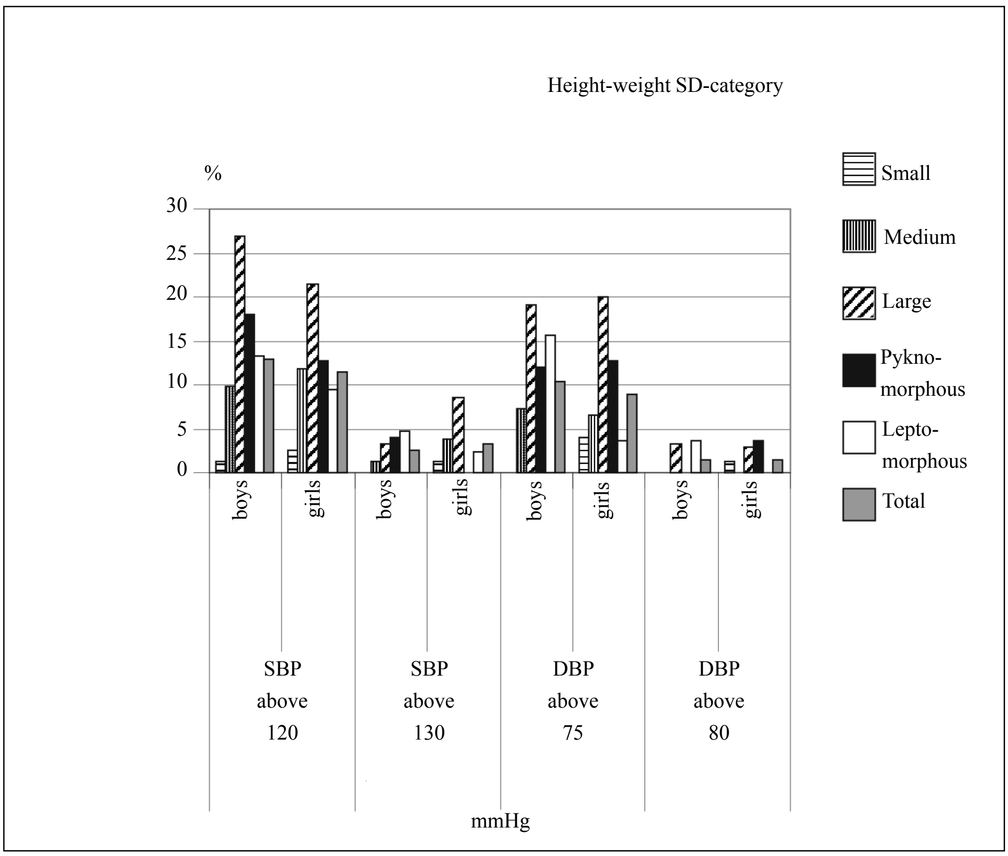

Fig. 8. Elevated blood pressure values (%) in boys and girls of different height-weight SD categories (SBP – systolic blood pressure; DBP – diastolic blood pressure)

Consistently with the previous data (37), boys of our study had elevated blood pressure more often than girls of the same age, though it is well known that girls mature earlier than boys and so reach their adult blood pressure sooner (38).

The analyses of relations between HW-category and BP pointed out the influence of body size on BP values, especially in boys. It seems that in the aspect of BP for adolescent boys it is important not to be to too large as for girls, but also not to be *leptomorphous*. It should be mentioned that just leptomorphous body build is prevailing among Estonian boys aged 12–15. Also for a part of Estonian children the underweight is becoming a problem (39).

The data of the present study showed that the percentages of Tartu boys and girls with both systolic and diastolic hypertension are significantly higher than those in Tallinn children reported by Suurorg and Tur (37), though the mean values of SBP and DBP were lower in Tartu children than in same age Tallinn children (37) or in Lithuanian children (40). Differences in BP values of different studies are in concordance with the study results of Suurorg and Tur (37) who found large regional differences in systolic and diastolic hypertension (0–18.2% and 0–13.6%, respectively) among Estonian children. Tallinn is the capital, the biggest town in Estonia (500 000 inhabitants), situated in North Estonia. Tartu is the second largest Estonian town (100 000 inhabitants) and situated in South Estonia.

The summarised results of our study highlighted that body build (height-weight SD-classes) have a small, but significant impact on the arterial BP. Our study suggested that it could be reasonable to screen the blood pressure of *large* children (children, who are tall and heavy for their age) and also boys of discordant HW-categories, especially *leptomorphous* boys. Future longitudinal studies are needed to clarify whether extreme leptomorphs are at the higher risk of elevated BP.

CONCLUSIONS

The use of height-weight SD classification allows finding out whether the differences in the variables studied are related to the body build as a whole or not.

Advantages of usage of HW-classification could be summarised as follows:

1. The height-weight classification allows showing visually that differences in body build are related to the differences in the variables studied (in sexual development and blood pressure). Belonging to an extreme (*small* or *large*) body height-weight category or to a height-weight discordant category could be more often related with the differences in sexual maturation signs and blood pressure. Therefore, not only extreme body height-weight but also the discordance between body weight and height could be disadvantageous in children's growth process and could be associated with stunted development.

2. Regardless of the great variability by age groups, the internal structure of body build is the same in all age groups even in the adolescence period (17). Consequently, it would be justified to use the five-class height-weight classification for simultaneous comparison of different age groups. In the future, it could be helpful in finding the better criteria for the assessment of physical disorders if we take into consideration the body build peculiarities of the person.

3. Since this classification can be used even if we have only the subject's body height and weight (the measurements that we usually have in medical studies), it is applicable in most respective studies.

4. This method could be used for comparative systematization of different anthropometrical parameters (length, breadth and depth measurements, circumferences and body characteristics, body proportions) that reflect the subject's physical status.

5. The height-weight classification is usable as a basis for analysing whether the differences in distinct persons are related to their body builds as a whole or not, when different characteristics (anthropometrical or physiological parameters or fitness indicators) of these persons are studied.

Summarising, we suggest using the height-weight SD classification for systematisation of the characteristics of the human body as a whole in order to study clinical and physiological data of different persons even in adolescent period.

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