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ANALYSIS OF BODY BUILD AND PHYSICAL ABILITIES OF VOLLEYBALL PLAYERS AGED 10–12 YEARS

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ABSTRACT

The aim of the study was to analyse the body build and physical abilities of 10–12-year-old volleyball players in order to identify the most promising young volleyball players in Estonia. The following research tasks were set: to find the anthropometric variables and physical abilities tests results of young volleyball players based on age classes and individually, to establish the body build types of young volleyball players based on a 5 SD height-weight classification, to find statistically significant differences in body build types in individual anthropometric variables and physical abilities tests, and to give an assessment to the results of the physical abilities tests and indicators of height, arm reach, body type, wrist circumference and lower leg circumference to find in which indicators volleyball players exceed the mean results of their age group. In total, 232 young volleyball players participated in the study – 118 players in the first measurement session and 114 players in the second measurement session. The following physical abilities tests were used in the study: hand grip test, reaction test, T-test, 5-0-5 run test, jump height tests (with and without arm swing) and step frequency test. The measured anthropometric variables were height, weight, arm reach, fat percentage, amount of fat, lower leg, wrist and waist circumferences. For data analysis, the Microsoft Excel program was used. To compare the mean results of the groups, Student's t-test was used. The results revealed that there were differences in both boys and girls between 10- and 12-year-olds and in some cases also between 11-year-olds and 12-year-olds in almost all anthropometric variables and physical ability test results. Older volleyball players received better results. Regarding the differences between the measurement sessions in the results of physical abilities tests and anthropometric variables, no definite pattern was formed that the results would improve in all age groups and sexes.

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This could be caused by the fact that not exactly the same volleyball players participated in both measurement sessions. When the volleyball players were divided into body build classes based on a 5 SD height-weight classification, it was revealed that statistically significant differences between classes occurred in all anthropometric characteristics. In physical ability tests, the results improved statistically significantly in the direction from small to medium and large classes and were always better in leptomorphs than in pycnomorphs. The players who exceeded the mean results of their age group in the results of the physical ability tests and based on certain body composition indicators received points for being promising. By adding up the points, the potentiality score was formed. Players in each age group whose score was higher than the mean score of their age group were considered more promising. We are of the opinion that, for Estonia to be successful compared to other countries in a sport like volleyball, we need to direct our resources to the search and development of young talents, because, with such a small population, we should not overlook a single young person who is a potential player of the national team.

Keywords: *young volleyball players; physical abilities tests; body build; talent identification*

INTRODUCTION

As Estonia's population is relatively small, for Estonian women's and men's national volleyball teams to remain competitive compared to other countries in the future, a systematic approach to young volleyball players is necessary to select and find the most talented players in terms of physical abilities at an early age. The coaches of youth teams would then start keeping an eye on them. The coaches would invite the most talented players from across Estonia to camps and training sessions and organize special competitions and test matches for them. In the future, it would be possible to draw up special training programmes that develop players' physical abilities. In order to realize the idea, Kert Toobal, the long-time captain of the Estonian national team, launched the "I am a Future Star" programme at the Estonian Volleyball Federation, on the basis of which an invitation was sent to all volleyball coaches of Estonia to participate with their most talented girls and boys in the measurement day in Paide on 15–16 June 2023. The next similar measurement session took place in Türi on 3–4 January 2024. Coaches as well as parents were informed that participation in the talent programme was strictly voluntary. The only restriction was that each coach could recommend or take along 3–4 students from each age group of 10–12-year-old children of his/her training group to the talent identification day. Talent identification is the process of finding young people who have more potential to acquire the top-level abilities necessary to perform a certain activity at the highest level in a chosen sport [3]. Outstanding talent means clearly above average sports skills compared to others of the same age as well as the potential to be successful at a higher competitive level [4]. D. J. Burgess and G. A. Naughton [5] have stated that, despite its complexity, talent development is a worthwhile investment in professional team sports. The search for young talents starts early, from among children aged nine and ten years or even younger [4]. A. Abbott and D. Collins [2] have stated that traditional talent identification models have measured children's physical and performance variables that are considered prerequisites for success in a particular sport, and tests have been used to identify those children who possess the necessary characteristics to succeed in a particular sport. A working group of volleyball coaches and sports scientists was formed to carry out the testing of children and to provide sample training sessions how to teach technical elements. The task of the working group was to draw up a complex of anthropometric measurements and physical and psychophysiological tests based on the literature and the opinions of current Estonian professional coaches and volleyball researchers, the results of which could predict the most successful volleyball players in the future. Several requirements were set for the test complex. First, they should be the simplest possible non-invasive field tests which could be administered in gym conditions. They should not be excessively tiring for the student, be attractive and exciting for children so that they would want to know their results. They should be as short as possible, so that all the children tested could visit the same testers during one testing day. At the same time, they should be informative and provide as versatile information as possible about the abilities and body measurements necessary for volleyball. By systematizing the body build data, the authors found to which body build class each subject belonged according to the 5 SD height-weight classification and, based on that, gave an assessment of their potential to play volleyball.

MATERIAL AND METHODS

The subjects were young volleyball players aged 10–12 years, both boys and girls, who had been selected by their own coaches. Each coach could bring 3–4 most talented players of his/her training group to the talent day. Thus, the best players from training groups from all over Estonia gathered for testing. On

15–16 June 2023, a total of 118 subjects participated in the talent day – 76 girls and 42 boys. The second talent day took place six months later (on 3–4 January 2024) with a total of 114 subjects, 70 of whom were girls and 44 were boys. Young volleyball players and their coaches agreed to participate in this study voluntarily. The players were accompanied by their coaches or parents.

Testing was carried out by a testing group of four members. In both testing sessions, girls were under observation on the first day and boys on the second day. The procedure was the following: a warm-up was done together; next, one age group (12-year-olds) went to take measurements and tests, and, at the same time, the other two age groups went to the courts with volleyball coaches. After that, the next age group (11-year-olds) went to take tests, and the other two age groups to the courts, and, finally, the last age group (10-year-olds) went to take the tests and the other two age groups to the courts.

The measuring and testing procedure was as follows: first, anthropometric measurements were taken: **height** (with an anthropometer, with an accuracy of 0.1 cm), **weight** (with an electronic scale with an accuracy of 0.01 kg), **arm reach** (with a measuring tape, standing by the wall, with an accuracy of 0.1 cm), body composition indicators (with Body Fat Monitor Omron BF300, **fat percentage** with 0.1% accuracy and **fat amount** with 0.1 kg accuracy), **lower leg, wrist and waist circumferences** (with measuring tape with 0.1 cm accuracy). The tests were performed as follows – hand grip test (with a hand dynamometer, with an accuracy of 1 kg), 5-0-5 run test (with an accuracy of 0.01 sec), jump tests – jump without arm swing, jump with arm swing (jump height with an accuracy of 0.1 cm and force exerted in jump with an accuracy of 0.01 W), **step frequency test** (number of repetitions and average contact time of each foot with the ground with an accuracy of 0.001 sec), **reaction test** (number of repetitions and reaction time with an accuracy of 0.001 sec) and **T-test** (with an accuracy of 0.01 sec). The step frequency test was performed only in January. In the first testing session, 10- and 11-year-old girls were not tested in the T-test.

Descriptions of tests

1. Hand grip test

Aim: To test hand grip strength with both the right and the left hand. Equipment: SAEHAN Hydraulic Hand Dynamometer (Model SH5001) – special hand dynamometer.

2. Reaction test

The reaction test is based on the methodology of R. E. Reigal et al [20] for measuring the reaction time. In the test conducted by them, the subject sat behind a table (one meter above the ground) and a choice reaction was used (two colours, one colour could only be touched with the right hand and the other colour only with the left hand). The test used in our study was slightly modified, the subject was kneeling on the ground and could press with both hands; only one colour was used on the reaction lights.

Aim: To test the speed of response to a visual stimulus. Equipment: 6 BlazePod (BlazePod Trainer Kit) reaction lights. The reaction speed was measured within 30 seconds; the subject had to react quickly by pressing the lighted reaction light.

3. 5-0-5 run test

The 5-0-5 run test has been taken from the book *100 mängu ja testid võrkpalli-treenerile ja liikumise õpetajale* (*100 Games and Tests for the Volleyball Coach and Teacher of Physical Education*) written by Raini Stamm [25]. The original description comes from the book *Developing Agility and Quickness* by Jay Dawes and Mark Roozen [9].

Aim: To test speed at slowing down and accelerating and at changes of direction Equipment: Microgate WITTY (Wireless Training Timer ver.3.38.44) timing gate system, measuring tape and 6 cones (see Figure 1).

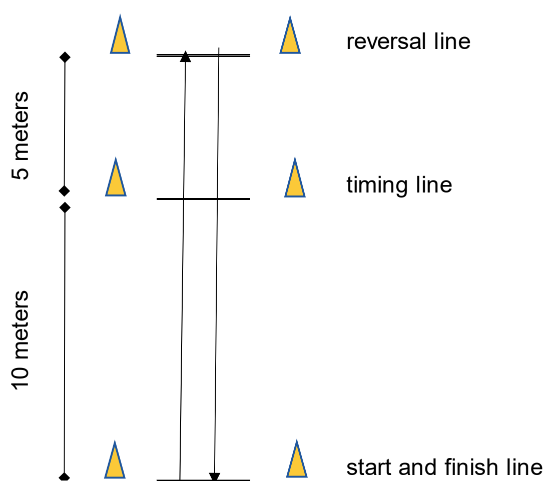

Figure 1. 5-0-5 run test [9].

4. T-test

The T-test has been taken from the book *100 mängu ja testid võrkpallitreenerile ja liikumise õpetajale* (*100 Games and Tests for the Volleyball Coach and Teacher of Physical Education*) by Raini Stamm [25]. This is an adapted test (originally from the book *Developing Agility and Quickness* by Jay Dawes and Mark Roozen [9]) that uses the metric scale, and the test has been slightly modified to use the dimensions of the volleyball court (a 9 × 9-meter area was used instead of 10 × 10 meters; see Figure 2).

Aim: To test the subject's ability to accelerate and slow down, assess the speed of changing direction and the stability of the body when moving forwards, backwards and sideways.

Equipment: Microgate WITTY (Wireless Training Timer ver.3.38.44) timing gate system.

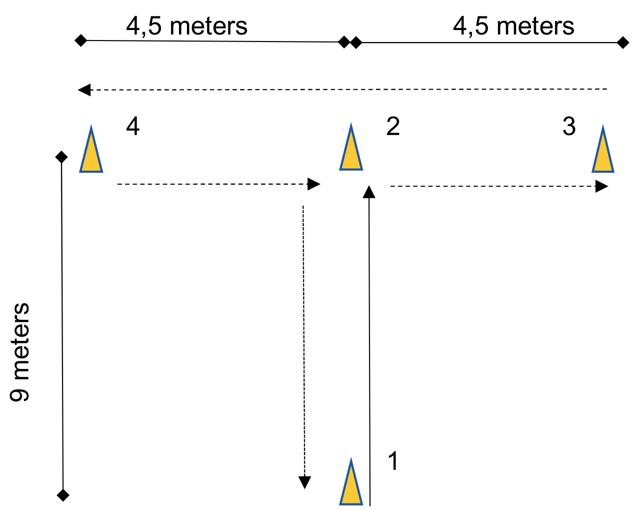

Figure 2. T-test [9, 25]

5. Jump height tests (without and with hand swing)

Jump height tests are based on the study by J. F. Glatthorn et al. [11] where jump height was measured without and with arm swing using the Microgate OptoJump system. The subject first performed three jumps with hands on hips and then three jumps with arm swing. The best results were recorded.

6. Step frequency test

The step frequency test is based on a study by S. Chaaboun et al. [7] where a step frequency test was performed for 4 seconds using the Microgate OptoJump system. Aim: To test the step frequency ability. Equipment: Microgate Opto-Jump system. Testing procedure: The subject attempted to take as many steps as s/he could within 15 seconds. The number of repetitions and the contact time of each foot with the ground (in seconds) were measured.

For data analysis, the Microsoft Excel program was used. The minimum and maximum results, averages and standard deviations were calculated for both boys and girls, considering the subjects' individual height and weight both within age groups and based on body build. To compare the mean results of the groups, Student's t-test was used. The level of statistical significance was set at $p < 0.05$.

To assess body build, a 5 SD height-weight classification was used by which the body build types (small, medium, large, leptomorphic, pycnomorphic) of all subjects were established (see Figure 3). The horizontal x-axis in the figure is the weight axis, and the vertical y-axis is the height axis, while x in the figure represents the mean result.

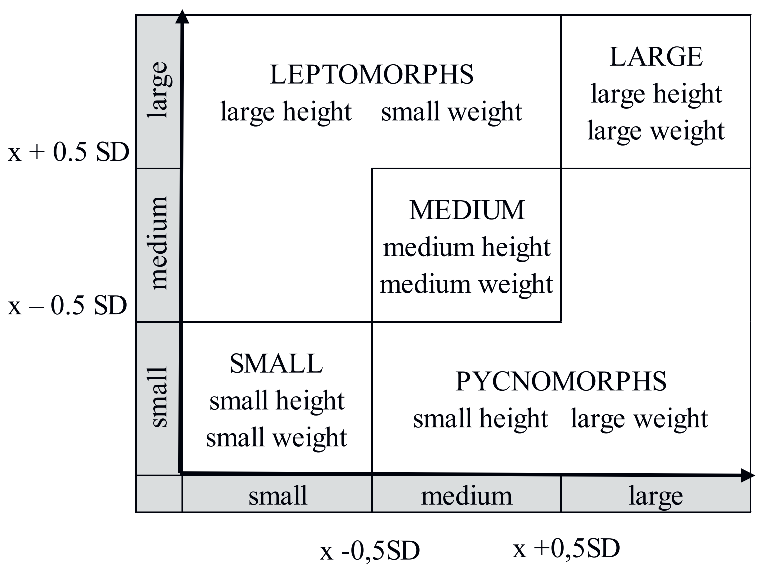

Figure 3. 5 SD height-weight classification

According to this figure, all volleyball players were placed in a class according to their individual height and weight, and the means of individual anthropometric characteristics and physical fitness tests results were calculated for each class. Then, the average results of the subjects' physical ability tests were viewed by classes, and statistically significant differences between classes were calculated using Student's t-test. The means of the subjects' anthropometric variables were also viewed by classes, and statistically significant differences between classes were calculated using Student's t-test.

First, based on the results, we singled out these students who exceeded the mean results of their age group in terms of anthropometric variables and physical abilities. In terms of body build, we considered height, arm reach, wrist circumference, lower leg circumference and belonging to the large or leptomorphic body build class the determining features of showing potential. If a player exceeded the mean of his/her age group in these characteristics, s/he received one point for each characteristic. As for physical tests, we considered the results of all tests. We added the potentiality points of each individual and received the potentiality score. The volleyball players who exceeded the mean score in their age group were considered showing greater potential.

RESULTS

Figure 4 shows the age distribution of boys and girls in the study.

Table 1 shows the mean results, SD, and minimum and maximum values of the body build and physical abilities variables for boys and Table 2 for girls in the first and second measurement sessions separately and together, and the statistically significant difference between the measurement sessions.

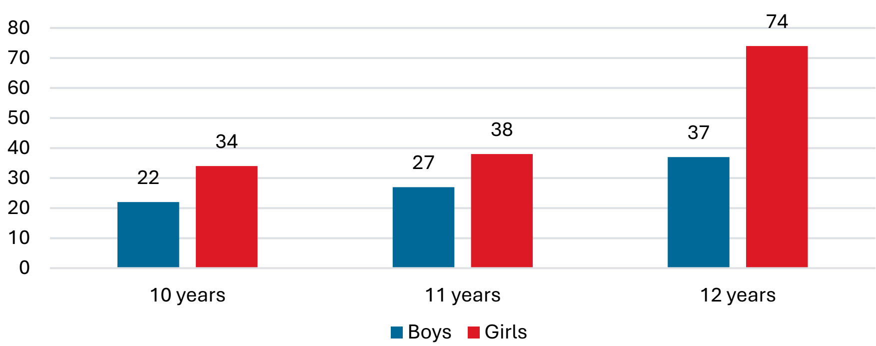

Figure 4. Age distribution of boys and girls in the study.

Table 1. Mean results, SD and minimum and maximum values of boys' body build and physical abilities variables separately and in total in the first and the second measurement sessions and statistically significant difference between the measurement sessions

* statistically significant difference between the first and the second measurement session is shown in red ($p < 0.05$)

Subjects	Number of subjects (n)	Mean, SD, min and max values	Height (cm)	Weight (kg)	BMI	Arm reach (cm)	Wrist circumference (cm)	Waist circumference (cm)	Lower leg circumference (cm)	Fat %	Fat amount (kg)	Hand strength (kg)		Reaction		T-test (sec)	5-0-5 run test (sec)	Step frequency test		
												Left	Right	Points	Mean time (sec)			Repetitions	Right (sec)	Left (sec)
Boys aged 10 (1st measurement)	n = 12	mean	150.0	39.1	17.3	194.1	14.8	64.3	20.4	21.4	8.5	19	20	41	0.552	12.68	2.8	–	–	–
		SD	5.8	5.0	1.5	8.8	0.7	3.3	1.1	5.5	3.0	2	2	3	0.055	0.85	0.2	–	–	–
		min	139.9	31.2	14.6	182.0	14.0	59.0	18.5	8.9	2.8	18	18	36	0.448	11.38	2.6	–	–	–
		max	160.4	47.9	19.7	210.0	16.5	68.0	22.0	28.1	13.4	23	26	48	0.646	14.29	3.1	–	–	–
Boys aged 10 (2nd measurement)	n = 10	mean	152.4	41.2	13.5	197.5	14.5	65.9	21.0	23.9	10.5	21	22	41	0.532	12.55	2.9	123	0.132	0.132
		SD	5.5	7.3	2.2	8.0	0.8	5.9	1.2	4.3	4.0	4	5	3	0.051	0.73	0.3	16	0.023	0.015
		min	142.7	34.0	11.7	184.5	13.5	60.5	19.0	15.3	5.2	16	15	36	0.453	11.40	2.5	91	0.107	0.105
		max	160.2	57.1	18.7	210.5	16.0	80.0	22.5	30.0	19.6	27	32	45	0.607	13.42	3.3	144	0.190	0.149
Boys aged 10 total	n = 22	mean	151.1	40.1	15.6	195.6	14.7	65.0	20.7	22.5	9.4	20	21	41	0.543	12.62	2.9	123	0.132	0.132
		SD	5.7	6.1	2.7	8.4	0.8	4.6	1.1	5.0	3.5	3	4	3	0.053	0.79	0.2	16	0.023	0.015
		min	139.9	31.2	11.7	182.0	13.5	59.0	18.5	8.9	2.8	16	15	36	0.448	11.38	2.5	91	0.107	0.105
		max	160.4	57.1	19.7	210.5	16.5	80.0	22.5	30.0	19.6	27	32	48	0.646	14.29	3.3	144	0.190	0.149
Statistically significant difference between measurements			0.3410	0.4550	0.0002	0.3634	0.2869	0.4666	0.3037	0.2280	0.2138	0.1605	0.3115	0.8102	0.3789	0.7101	0.5041	–	–	–

Subjects	Number of subjects (n)	Mean, SD, min and max values	Height (cm)	Weight (kg)	BMI	Arm reach (cm)	Wrist circumference (cm)	Waist circumference (cm)	Lower leg circumference (cm)	Fat %	Fat amount (kg)	Hand strength (kg)		Reaction		T-test (sec)	5-0-5 run test (sec)	Step frequency test		
												Left	Right	Points	Mean time (sec)			Repetitions	Right (sec)	Left (sec)
Boys aged 11 (1st measurement)	n = 14	mean	152.6	42.4	18.1	196.3	15.0	65.9	20.9	19.5	8.6	22	21	44	0.508	12.63	2.8	–	–	–
		SD	5.5	7.5	2.2	7.3	1.1	5.5	1.5	6.6	4.1	3	4	3	0.057	0.58	0.2	–	–	–
		min	145.3	32.1	14.8	185.0	13.5	60.0	19.0	9.5	3.0	16	14	36	0.436	11.58	2.5	–	–	–
		max	161.4	57.9	22.4	208.5	17.0	80.0	24.0	32.4	18.8	27	28	49	0.656	13.86	3.1	–	–	–
Boys aged 11 (2nd measurement)	n = 13	mean	155.2	44.7	14.3	200.1	14.8	67.0	21.6	23.2	10.7	22	23	40	0.527	12.07	2.8	129	0.134	0.130
		SD	5.3	8.4	2.3	7.7	1.3	5.6	1.9	6.3	4.5	3	3	4	0.086	0.70	0.1	15	0.014	0.013
		min	147.7	33.8	11.2	189.5	13.0	60.0	19.0	10.5	3.5	17	18	32	0.430	11.26	2.7	94	0.116	0.111
		max	164.2	58.5	18.5	213.0	17.3	78.0	25.0	34.7	20.3	28	30	46	0.734	13.70	3.0	151	0.171	0.164
Boys aged 11 total	n = 27	mean	153.8	43.5	16.3	198.1	14.9	66.4	21.2	21.3	9.6	22	22	42	0.517	12.36	2.8	129	0.134	0.130
		SD	5.5	7.8	2.9	7.6	1.2	5.4	1.8	6.6	4.4	3	4	4	0.072	0.69	0.2	15	0.014	0.013
		min	145.3	32.1	11.2	185.0	13.0	60.0	19.0	9.5	3.0	16	14	32	0.430	11.26	2.5	94	0.116	0.111
		max	164.2	58.5	22.4	213.0	17.3	80.0	25.0	34.7	20.3	28	30	49	0.734	13.86	3.1	151	0.171	0.164
Statistically significant difference between measurements			0.2199	0.4697	0.0002	0.1977	0.6580	0.5958	0.2737	0.1584	0.2341	0.8530	0.3517	0.0463	0.5214	0.0353	0.1345	–	–	–

Subjects	Number of subjects (n)	Mean, SD, min and max values	Height (cm)	Weight (kg)	BMI	Arm reach (cm)	Wrist circumference (cm)	Waist circumference (cm)	Lower leg circumference (cm)	Fat %	Fat amount (kg)	Hand strength (kg)		Reaction		T-test (sec)	5-0-5 run test (sec)	Step frequency test		
												Left	Right	Points	Mean time (sec)			Repetitions	Right (sec)	Left (sec)
Boys aged 12 (1st measurement)	n = 16	mean	167.2	53.0	18.8	216.9	16.0	69.4	22.5	18.6	10.3	28	30	45	0.484	11.46	2.6	–	–	–
		SD	14.8	12.8	3.0	19.6	1.3	8.6	1.9	6.4	5.3	6	8	4	0.056	0.61	0.1	–	–	–
		min	150.7	36.2	15.3	193.0	14.0	60.0	19.0	9.3	3.7	21	20	37	0.397	10.09	2.4	–	–	–
		max	191.5	75.9	26.4	251.0	19.0	88.0	26.0	32.3	21.7	43	46	51	0.629	12.87	2.9	–	–	–
Boys aged 12 (2nd measurement)	n = 21	mean	160.9	52.4	16.2	209.6	15.6	71.6	22.6	20.0	11.1	28	29	41	0.517	11.70	2.8	137	0.124	0.127
		SD	8.0	11.0	2.9	11.9	1.0	8.2	1.7	7.9	6.1	6	6	2	0.044	0.81	0.1	10	0.014	0.015
		min	145.0	34.5	11.9	189.0	13.5	61.0	19.5	5.5	2.0	21	22	37	0.446	10.33	2.5	119	0.090	0.095
		max	171.1	74.9	22.6	228.0	18.0	89.5	25.0	32.9	23.3	47	41	45	0.590	13.11	3.1	162	0.147	0.150
Boys aged 12 total	n = 37	mean	163.6	52.6	17.3	212.8	15.8	70.6	22.6	19.4	10.8	28	30	43	0.503	11.60	2.7	137	0.124	0.127
		SD	11.7	11.7	3.2	15.9	1.2	8.3	1.8	7.2	5.7	6	6	4	0.052	0.73	0.1	10	0.014	0.015
		min	145.0	34.5	11.9	189.0	13.5	60.0	19.0	5.5	2.0	21	20	37	0.397	10.09	2.4	119	0.090	0.095
		max	191.5	75.9	26.4	251.0	19.0	89.5	26.0	32.9	23.3	47	46	51	0.629	13.11	3.1	162	0.147	0.150
Statistically significant difference between measurements			0.1363	0.8765	0.0137	0.1983	0.4228	0.4381	0.7508	0.5666	0.6959	0.7917	0.7607	0.0002	0.0600	0.3004	0.0106	–	–	–
Statistically significant difference between measurements			11+12 10+12	11+12 10+12	10+12	11+12 10+12	11+12 10+12	11+12 10+12	11+12 10+12	–	–	11+12 10+12	11+12 10+12	10+12	10+12	11+12 10+12	11+12 10+12	10+12	–	–

In Table 1, we have presented the mean values, standard deviations (SD), and minimum and maximum values of boys' body build and physical abilities indicators separately for the first and second measurement sessions. We analysed the results of the first and second measurement sessions together. It could be seen that the mean height of 10-year-old boys was 151.1 cm and weight 40.1 kg, the mean height of 11-year-old boys 153.8 cm and weight 43.5 kg, and the mean height of 12-year-old boys 163.6 cm and weight 52.6 kg. Other anthropometric variables in boys' body build, such as neck circumference, wrist circumference, waist circumference, lower leg circumference and amount of fat, also increased with age, which is completely logical. Using Student's t-test, we also calculated the statistically significant difference between the results of the first and second measurement sessions. Height and weight did not differ, but BMI was statistically significantly different between the first and the second measurement sessions in all age groups ($p < 0.05$) (Table 1). In 11- and 12-year-old boys, there was also a statistically significant difference between the first and the second measurement sessions in the reaction test.

There were also statistically significant differences between the results of the first and second measurement sessions in the speed run T-test in 11-year-old boys and in the 5-0-5 run test in 12-year-old boys. As we administered the step frequency test only in the second measurement session, it is not possible to compare the results with the first measurement session, but, with an increase in age, the number of repetitions of the step frequency test also increased and the contact time of the right and the left foot with the ground decreased (Table 1). So far, we described the statistically significant differences between the first and the second measurement sessions, but now we are going to consider the statistically significant differences between the age groups.11-year-old boys were statistically significantly different in height from 12-year-old boys and 10-year-old boys from 12-year-old boys. Exactly the same statistically significant differences appeared for weight – 11-year-olds versus 12-year-olds and 10-year-olds versus 12-year-olds.

In body mass index, there was a statistically significant difference between the age groups of 10-year-olds and 12-year-olds. There were statistically significant differences between 11-year-olds and 12-year-olds and between 10-year-olds and 12-year-olds in arm reach, wrist circumference, waist circumference, and lower leg circumference. There were no statistically significant differences between the age groups in fat indicators. In the physical ability tests – hand grip (with both right and left hand), T-test and 5-0-5 run test – statistically significant differences appeared between 11-year-olds and 12-year-olds and between 10-year-olds and 12-year-olds. In the reaction test (points and average time) and the step frequency test (number of repetitions), there were statistically significant differences only between 10-year-olds and 12-year-olds. There was no statistically significant difference between the age groups in the contact time of the right and the left foot in the step frequency test, although it was numerically evident that the time decreased with the increase in age when 11-year-olds and 12-year-olds were compared (Table 1).

Table 2 shows the mean results, standard deviations, and minimum and maximum values of the girls' body build and physical abilities indicators also for the first and second measurement sessions separately, and statistically significant differences between the measurement sessions. The mean height of 10-year-old girls was 152.7 cm, of 11-year-olds 157.2 cm, and of 12-year-olds 164.5 cm; hence, there was a gradual increase in the girls' mean height. The mean weight of 10-year-old girls was 44.1 kg, of 11-year-olds 45.6 kg and of 12-year-olds 53.5 kg. There was a statistically significant difference in BMI between the first and the second measurement sessions in all age groups. In the hand grip test, there was a statistically significant difference between the measurement sessions results in the groups of 11-year-olds and 12-year-olds. In both cases, the strength of the right hand was greater in the second measurement. In the reaction test, 12-year-old girls scored statistically significantly worse in the second measurement session. The mean time in the reaction test was smaller in all age groups in the second measurement session than in the first, which is a positive result. In the 5-0-5 run test, 11-year-olds scored statistically significantly worse in the second measurement session than in the first. Individual variables of girls' body build generally increased gradually in age groups for such indicators as neck circumference, waist circumference, lower leg circumference, wrist circumference, amount of fat, and percentage of fat. The mean indicators of hand strength also increased with age. As we administered the step frequency test only in the second measurement session, it was not possible to compare the results with the first measurement session, but, with an increase in age, the number of repetitions of the step frequency test also increased and the contact time of both feet with the ground decreased (Table 2). Table 2 also shows the statistically significant difference between the girls' age groups. There was a statistically significant difference in height and arm reach between all age groups (10 and 11, 11 and 12, 10 and 12). In weight, BMI, wrist circumference and lower leg circumference, there were statistically significant differences between 10-year-olds and 12-year-olds and between 11-year-olds and 12-year-olds. There was no statistically significant difference between the age groups in waist circumference. Fat indicators were higher in 10-year-olds than in 11-year-olds and again higher in 12-year-olds than in 11-year-olds. Hand

Table 2. Mean results, SD and minimum and maximum values of girls' body build and physical abilities variables separately and in total in the first and the second measurement sessions and statistically significant difference between the measurement sessions

* statistically significant difference between the first and the second measurement session is shown in red ($p < 0.05$)

Subjects	Number of subjects (n)	Mean, SD, min and max values	Height (cm)	Weight (kg)	BMI	Arm reach (cm)	Wrist circumference (cm)	Waist circumference (cm)	Lower leg circumference (cm)	Fat %	Fat amount (kg)	Hand strength (kg)		Reaction		T-test (sec)	5-0-5 run test (sec)	Step frequency test		
												Left	Right	Points	Mean time (sec)			Repetitions	Right (sec)	Left (sec)
girls aged 10 (1st measurement)	n = 17	mean	151.3	42.5	18.4	194.4	14.9	64.4	20.9	22.6	10.0	20	20	40	0.568	–	2.9	–	–	–
		SD	8.8	9.4	2.4	11.4	1.0	6.1	1.9	4.7	3.5	4	4	3	0.059	–	0.1	–	–	–
		min	140.3	30.0	15.0	179.0	13.5	57.0	18.0	14.2	5.7	12	14	35	0.475	–	2.7	–	–	–
		max	165.7	62.9	24.0	215.0	17.0	82.0	25.0	32.1	20.2	27	27	46	0.684	–	3.2	–	–	–
girls aged 10 (2nd measurement)	n = 17	mean	154.0	45.7	14.7	198.6	14.6	66.6	21.6	25.4	12.1	20	21	40	0.541	13.26	3.1	124	0.139	0.143
		SD	8.7	13.4	3.5	11.2	1.3	8.7	2.4	5.3	6.1	4	4	2	0.046	0.78	0.3	11	0.021	0.020
		min	142.4	30.4	10.4	180.0	13.0	58.0	17.0	16.7	5.9	14	15	34	0.484	11.76	2.6	101	0.115	0.115
		max	174.0	72.2	21.2	219.0	17.0	85.0	27.0	36.3	24.4	28	29	43	0.637	14.30	3.7	139	0.182	0.174
girls aged 10 total	n = 34	mean	152.7	44.1	16.5	196.5	14.8	65.5	21.3	24.0	11.1	20	21	40	0.555	13.26	3.0	124	0.139	0.143
		SD	8.7	11.5	3.5	11.3	1.2	7.5	2.2	5.1	5.0	4	4	3	0.054	0.78	0.2	11	0.021	0.020
		min	140.3	30.0	10.4	179.0	13.0	57.0	17.0	14.2	5.7	12	14	34	0.475	11.76	2.6	101	0.115	0.115
		max	174.0	72.2	24.0	219.0	17.0	85.0	27.0	36.3	24.4	28	29	46	0.684	14.30	3.7	139	0.182	0.174
Statistically significant difference between measurements			0.3654	0.4263	0.0011	0.2957	0.4929	0.3916	0.3566	0.1222	0.2282	0.7380	0.8377	0.7582	0.1496	–	0.1204	–	–	–

Subjects	Number of subjects (n)	Mean, SD, min and max values	Height (cm)	Weight (kg)	BMI	Arm reach (cm)	Wrist circumference (cm)	Waist circumference (cm)	Lower leg circumference (cm)	Fat %	Fat amount (kg)	Hand strength (kg)		Reaction		T-test (sec)	5-0-5 run test (sec)	Step frequency test		
												Left	Right	Points	Mean time (sec)			Repetitions	Right (sec)	Left (sec)
girls aged 11 (1st measurement)	n = 17	mean	156.1	43.6	17.9	201.5	14.7	64.7	21.1	21.1	9.3	21	21	43	0.510	–	2.8	–	–	–
		SD	5.7	5.0	1.8	7.0	0.5	4.2	1.5	5.0	3.1	4	4	3	0.050	–	0.1	–	–	–
		min	147.2	35.3	15.5	192.5	14.0	59.0	19.0	13.5	4.8	16	16	38	0.419	–	2.5	–	–	–
		max	171.6	55.7	23.3	219.0	15.5	77.0	23.5	33.4	18.6	30	31	50	0.605	–	3.0	–	–	–
girls aged 11 (2nd measurement)	n = 21	mean	158.0	47.2	14.9	203.5	14.9	66.3	21.8	21.4	10.3	23	24	43	0.491	12.31	2.9	131	0.131	0.137
		SD	5.9	7.0	1.9	8.5	0.8	5.6	1.5	5.0	3.7	4	4	3	0.047	0.74	0.1	15	0.012	0.024
		min	147.9	36.4	12.0	187.0	13.5	57.0	19.5	13.4	4.9	17	15	37	0.405	10.91	2.7	97	0.106	0.112
		max	169.7	60.5	18.2	220.5	16.0	78.0	24.5	31.1	17.5	31	31	50	0.591	14.01	3.2	152	0.151	0.220
girls aged 11 total	n = 38	mean	157.2	45.6	16.2	202.6	14.8	65.6	21.5	21.3	9.9	22	22	43	0.499	12.31	2.8	131	0.131	0.137
		SD	5.8	6.4	2.4	7.8	0.6	5.1	1.5	4.9	3.4	4	4	3	0.049	0.74	0.1	15	0.012	0.024
		min	147.2	35.3	12.0	187.0	13.5	57.0	19.0	13.4	4.8	16	15	37	0.405	10.91	2.5	97	0.106	0.112
		max	171.6	60.5	23.3	220.5	16.0	78.0	24.5	33.4	18.6	31	31	50	0.605	14.01	3.2	152	0.151	0.220
Statistically significant difference between measurements			0.3137	0.0709	0.0002	0.4384	0.3814	0.3327	0.1898	0.8283	0.3556	0.0973	0.0238	0.7886	0.2500	–	0.0003	–	–	–

Subjects	Number of subjects (n)	Mean, SD, min and max values	Height (cm)	Weight (kg)	BMI	Arm reach (cm)	Wrist circumference (cm)	Waist circumference (cm)	Lower leg circumference (cm)	Fat %	Fat amount (kg)	Hand strength (kg)		Reaction		T-test (sec)	5-0-5 run test (sec)	Step frequency test		
												Left	Right	Points	Mean time (sec)			Repetitions	Right (sec)	Left (sec)
girls aged 12 (1st measurement)	n = 42	mean	163.9	53.8	20.0	212.1	15.6	67.5	22.7	21.9	12.1	25	26	45	0.489	12.12	2.8	–	–	–
		SD	7.0	8.2	2.4	9.6	0.8	5.0	1.6	5.0	4.3	4	4	4	0.063	0.86	0.2	–	–	–
		min	149.4	37.9	15.5	189.5	14.0	59.0	19.0	11.5	5.6	15	18	36	0.384	10.28	2.4	–	–	–
		max	178.6	70.6	25.9	235.0	17.5	79.0	26.0	32.5	21.5	37	33	53	0.650	14.46	3.0	–	–	–
girls aged 12 (2nd measurement)	n = 32	mean	165.2	53.1	16.0	213.0	15.2	67.1	22.6	22.2	12.1	27	29	43	0.482	12.23	2.9	134	0.130	0.132
		SD	6.5	8.5	2.2	8.9	0.8	4.6	1.3	4.6	3.9	6	7	3	0.048	0.81	0.2	15	0.017	0.013
		min	150.0	32.6	10.9	189.5	12.5	60.0	18.5	16.2	6.8	18	14	37	0.401	10.90	2.3	100	0.107	0.104
		max	176.8	68.7	20.8	226.0	16.5	78.0	24.5	31.8	21.4	43	46	49	0.598	13.65	3.4	164	0.188	0.155
girls aged 12 total	n = 74	mean	164.5	53.5	18.3	212.5	15.5	67.3	22.7	22.0	12.1	26	27	44	0.486	12.17	2.8	134	0.130	0.132
		SD	6.7	8.3	3.0	9.2	0.8	4.8	1.5	4.8	4.1	5	6	4	0.057	0.83	0.2	15	0.017	0.013
		min	149.4	32.6	10.9	189.5	12.5	59.0	18.5	11.5	5.6	15	14	36	0.384	10.28	2.3	100	0.107	0.104
		max	178.6	70.6	25.9	235.0	17.5	79.0	26.0	32.5	21.5	43	46	53	0.650	14.46	3.4	164	0.188	0.155
Statistically significant difference between measurements			0.4397	0.7047	0.0004	0.6827	0.0338	0.6922	0.6639	0.7880	0.9352	0.1650	0.0298	0.0332	0.6139	0.5672	0.1135	–	–	–
Statistically significant difference between measurements			10+11 11+12 10+12	11+12 10+12	11+12 10+12	10+11 11+12 10+12	11+12 10+12	–	11+12 10+12	10+11	11+12	11+12 10+12	11+12 10+12	10+11 10+12	10+11 10+12	10+11 10+12	10+11 10+12	10+12	–	10+12

grip, reaction test and running tests (T-test, 5-0-5 run test) results improved with age, in many cases statistically significantly. The number of repetitions in the step frequency test also increased with the increase in age. A statistically significant difference appeared between 10-year-olds and 12-year-olds. The contact time with the ground with both the right and the left foot improved with increasing age, and a statistically significant difference appeared for the result of the left foot between 10-year-olds and 12-year-olds (Table 2).

Distribution of volleyball players into body build classes according to the 5 SD height-weight classification

We calculated the limits of the 5 SD height-weight classes for the entire sample for boys and girls separately using their mean height, mean weight and the corresponding standard deviations. We received five standard deviation classes – small height, small weight; medium height, medium weight; large height, large weight; large height, small weight (leptomorphs) and small height, large weight (pycnomorphs). In the first three classes (small, medium, large), weight and height are in correspondence. In the fourth class (leptomorphs), relative height exceeds relative weight, and in the fifth class (pycnomorphs), relative weight exceeds relative height. In the last two classes, height and weight are not in correspondence (see Figure 3).

Table 3 shows the means, standard deviations, and minimum and maximum values of boys' physical ability tests results in the 5 SD height-weight classes. 20 boys were placed into the small class with small height and small weight. The medium class with medium height and medium weight included 23 boys. The large class with large height and large weight included 16 boys. 14 boys belonged to the class of leptomorphs with large height and small weight (a non-conformity class). 13 boys belonged to the class of pycnomorphs with small height and large weight (a non-conformity class). Table 3 also shows that the results of all the 13 indicators tested in the physical ability tests were better in boys belonging to the class of leptomorphs than in boys of the class of pycnomorphs. Only the leptomorphs' left hand was as strong as the pycnomorphs' left hand. In the small, medium and large classes, the results improved towards the large class and were always better for large than for small or medium. In boys, when the mean results of the classes were compared, the best results in most physical ability tests were obtained by the boys of the large class: in the hand grip test, the right hand 33 kg and the left hand 32 kg, the number of points in the reaction test 43 and the average time 0.495 sec, in the T test 11.78 sec, in the jump test with arms swing height 29.9 cm and force 14.9 W/kg and without arms swing

Table 3. Means, standard deviations, and minimum and maximum values of boys' physical ability tests results in 5 SD height-weight classes.

Body build classes	Number of subjects	Mean, SD, min and max	Hand strength (kg)		Reaction		T-test (sec)	5-0-5 run test (sec)	Jump without arms swing		Jump with arms swing		Step frequency test		
			Left	Right	Points	Mean time (sec)			Height (cm)	Strength (W/kg)	Height (cm)	Strength (W/kg)	Repeti-tions	Right (sec)	Left (sec)
Small class	20	mean	20	20	42	0.522	12.16	2.77	20.6	12.2	26.5	12.9	130.56	**0.100**	**0.120**
		SD	3.4	3.5	3.3	0.05	0.9	0.2	6.3	2.9	6.5	2.2	8.0	0.014	0.015
		min	15	14	36	0.446	10.93	2.54	12.5	8.3	15.8	9.3	120	0.090	0.095
		max	27	28	48	0.607	14.29	3.13	32.9	18.6	38.3	18.2	142	0.145	0.149
Medium class	23	mean	24	23	41	0.521	12.15	2.79	21.8	13.2	26.7	14.2	126.57	0.130	0.130
		SD	3.4	2.9	3.9	0.1	0.8	0.1	5.1	3.1	4.6	2.4	16.7	0.020	0.010
		min	18	19	34	0.421	10.87	2.45	11.0	8.6	15.7	9.9	91	0.105	0.119
		max	32	27	50	0.651	13.49	3.07	29.8	21.2	34.8	20.0	151	0.190	0.149
Large class	16	mean	**32**	**33**	**43**	**0.495**	**11.78**	2.75	**24.8**	**14.9**	**29.9**	**14.5**	133.64	0.130	0.130
		SD	6.3	7.3	2.8	0.05	0.9	0.2	4.6	3.8	5.1	2.4	10.3	0.007	0.013
		min	23	24	37	0.446	10.33	2.54	16.7	10.3	24.1	12.3	119	0.121	0.108
		max	43	47	46	0.590	13.70	3.06	33.3	23.3	40.5	19.6	148	0.144	0.150
Lepto-morph class	14	mean	24	25	**43**	0.507	11.81	**2.72**	22.3	12.6	28.5	14.3	**139.40**	0.110	**0.120**
		SD	4.7	6.2	4.5	0.1	0.9	0.2	3.6	2.3	4.2	2.0	14.1	0.010	0.015
		min	18	16	36	0.397	10.09	2.41	16.5	10.2	22.6	11.7	123	0.099	0.098
		max	32	40	51	0.646	13.17	3.32	29.1	18.8	33.9	18.5	162	0.125	0.135
Pycno-morph class	13	mean	24	24	41	0.544	12.6	2.88	17.2	11	21.8	11.8	132	0.140	0.130
		SD	4.3	3.2	4.1	0.1	0.7	0.1	2.9	1.7	3.9	1.4	21.5	0.020	0.020
		min	18	19	32	0.464	11.39	2.71	12.5	8.4	16.2	9.8	94	0.125	0.110
		max	32	32	46	0.734	13.86	3.15	23.2	14.8	29.8	14.5	145	0.171	0.164

Table 4. Means, standard deviations, and minimum and maximum values of girls' physical ability tests results in 5 SD height-weight classes.

Body build classes	Number of subjects	Mean, SD, min and max	Hand strength (kg)		Reaction		T-test (sec)	5-0-5 run test (sec)	Jump without arms swing		Jump with arms swing		Step frequency test		
			left	right	points	mean time (sec)			Height (cm)	Strength (W/kg)	Height (cm)	Strength (W/kg)	Repetitions	Right (sec)	Left (sec)
Small class	36	mean	19	19	42	0.529	12.88	2.92	17	12.6	21.6	12.65	128	**0.130**	**0.130**
		SD	3.1	3.1	3.5	0.1	1.0	0.2	4.2	3.2	4.1	2.0	13.7	0.015	0.017
		min	12	14	34	0.430	10.91	2.53	9.3	7.65	13.8	9.13	102	0.108	0.108
		max	25	25	49	0.684	14.30	3.67	26.8	21.46	30.9	17.12	149	0.169	0.168
Medium class	26	mean	24.19	23.23	43	0.497	12.4	2.89	**20.3**	**13.43**	24.9	13.72	129	0.140	0.140
		SD	5.6	5.1	8.4	0.1	0.8	0.6	5.1	3.2	6.0	3.0	16.8	0.019	0.012
		min	18	18	37	0.384	11.27	2.51	9.7	7.63	13.9	10.04	100	0.112	0.121
		max	32	31	53	0.605	13.82	3.38	28.5	17.74	35.9	17.18	164	0.188	0.164
Large class	36	mean	**28**	**28**	**44**	0.495	12.2	2.82	19	13.3	23.6	**13.8**	**135**	**0.130**	0.140
		SD	6.0	5.3	6.8	0.1	2.1	0.4	5.1	3.1	5.7	2.8	14.0	0.017	0.015
		min	15	22	37	0.406	10.90	2.56	10.6	8.2	13.3	8.8	101	0.109	0.104
		max	41	36	51	0.610	13.86	3.19	28.8	18.7	31.3	18.2	158	0.182	0.174
Lepto-morph class	30	mean	24.78	24.57	**44**	**0.493**	**11.98**	**2.78**	**20.3**	13.39	**25.3**	13.55	134	**0.130**	**0.130**
		SD	5.6	5.4	4.3	0.1	0.9	0.2	5.3	2.8	5.7	2.1	12.4	0.016	0.017
		min	15	18	36	0.401	10.28	2.26	8.5	7.1	14.2	9.3	105	0.106	0.111
		max	42	42	51	0.650	14.46	3.10	31.0	17.5	36.5	17.6	152	0.152	0.160
Pycno-morph class	18	mean	24.11	23.83	42	0.519	12.61	2.91	16.6	11.99	21	12.08	122	0.140	0.150
		SD	6.3	6.1	3.5	0.1	0.7	0.2	4.0	3.3	3.8	1.6	14.5	0.017	0.040
		min	16	18	35	0.433	11.61	2.60	11.0	8.66	15.0	9.57	97	0.122	0.119
		max	46	43	49	0.673	14.00	3.29	24.5	21.59	27.9	16.20	137	0.165	0.220

height 24.8 cm and force 14,9 W/kg. In the 5-0-5 running test and the step frequency test (number of repetitions and contact time of the left foot with the ground), the best results were obtained, compared with the mean results of the classes, by leptomorphic boys.

Table 4 shows the means, standard deviations, and minimum and maximum values of girls' physical ability tests results in the 5 SD height-weight classes. Each girl was placed into a class according to her individual height and weight. 36 girls were placed into the small class, 26 girls into the medium class, 36 girls in the large class; 30 girls were placed into the class of leptomorphs (large height and small weight) and 18 girls into the class of pycnomorphs class (small height and heavy weight). The same tendency as in boys' body build classes was also revealed in girls. In all physical ability tests, such as hand grip, reaction test points and mean time, T-test, 5-0-5 run test, jumps with both arm swing and without, the speed test and the step frequency test, the results of leptomorphs were better than those of pycnomorphs. The results improved gradually from the small to the medium and the large class considering the mean results of the hand grip test (left and right), the reaction test (both the points and the mean time), the speed run tests, the T-test and the 5-0-5 run test, the number of repetitions in the step frequency test and in force application in the jump with arms swing. The height of the jump and the exerted force without arms swing, the height of the jump with arm swing and the contact time of the right and the left foot with the ground in the step frequency test improved from the small to the medium class, but the results of these five characteristics in the large class did not exceed the results of the medium class (Table 4).

Mean values of anthropometric variables and physical ability test results and statistically significant differences between 5 SD body build classes

Table 5 shows the distribution of the boys' anthropometric variables into body build classes; the mean values of the classes have been calculated for each variable. Concerning the changes in body build according to the classes, Table 5 shows that all variables have statistically essential differences between the small, medium and large classes; only fat percentage has no statistically significant difference between the small and the medium classes (Figure 5).

Table 5. Distribution of boys based on the 5 SD height-weight classification where the mean values of anthropometric variables and statistically significant differences between classes have been calculated for each body build class (small, medium, large, leptomorphs, pycnomorphs) ($p < 0.05$)

* statistically significant differences between classes are shown in red

Anthropometric variables	Small class (n = 20) mean	Medium class (n = 23) mean	Large class (n = 16) mean	Statistically significant difference between classes 1–3	Lepto-morph class (n = 14) mean	Pycno-morph class (n = 13) mean	Statistically significant difference between classes 4–5
Height (cm)	147.0	156.2	173.1	1+2; 2+3; 1+3	159.0	154.1	4+5
Weight (kg)	35.4	45.0	62.8	1+2; 2+3; 1+3	41.9	51.4	4+5
BMI	14.5	16.0	18.6	1+2; 2+3; 1+3	15.4	19.6	4+5
Arm reach (cm)	189.2	202.7	225.3	1+2; 2+3; 1+3	206.5	198.7	4+5
Wrist circumference (cm)	14.2	15.2	16.6	1+2; 2+3; 1+3	14.7	15.9	4+5
Wrist circumference (cm)	61.8	67.2	75.3	1+2; 2+3; 1+3	63.4	74.1	4+5
Lower leg circumference (cm)	19.8	21.3	24.0	1+2; 2+3; 1+3	21.2	22.7	4+5
Fat %	18.1	21.3	23.1	1+3; 2+3	16.9	25.1	4+5
Fat amount (kg)	6.4	9.7	14.6	1+2; 2+3; 1+3	7.0	13.8	4+5

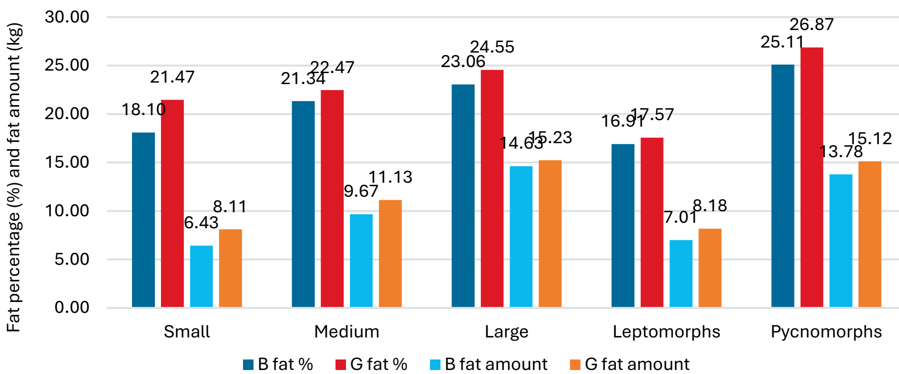

Figure 5. Mean values of fat percentage and amount of fat in boys (n=86) and girls (n=146) in 5 SD height-weight classes.

There was also a statistically significant difference between the leptomorphic and the pycnomorphic classes in all individual anthropometric characteristics of body build. Leptomorphs exceeded pycnomorphs in height and arm reach. On the other hand, pycnomorphs exceeded leptomorphs in weight, BMI, wrist circumference, waist circumference, lower leg circumference, fat percentage and amount of fat, and the differences were statistically significant (Table 5).

In physical ability tests in boys (Table 6), the results improved gradually and statistically significantly from the small to the medium and the large classes in the hand grip test for both the left and the right hand. Statistically significant differences occurred between classes 1 and 2, 1 and 3, 1 and 4, 1 and 5, 2 and 3, 3 and 4, and 3 and 5 where 1 is the small class, 2 the medium class, 3 the large class, 4 the class of leptomorphs and 5 the class of pycnomorphs (Figure 6).

Table 6. Distribution of boys based on the 5 SD height-weight classification where the mean results of physical abilities tests and statistically significant differences between classes have been calculated for each body build class (small, medium, large, leptomorphs, pycnomorphs) ($p < 0.05$)

* statistically significant differences between classes are shown in red

Physical abilities indicators		Small class (n = 20) mean	Medium class (n = 23) mean	Large class (n = 16) mean	Leptomorph class (n = 14) mean	Pycnomorph class (n = 13) mean	Statistically significant difference between classes 1–5
Hand strength (kg)	Left	20.2	23.7	32.3	23.9	24.3	1+2; 1+3; 1+4; 1+5; 2+3; 3+4; 3+5
	Right	20.2	22.9	33.3	24.6	23.8	1+2; 1+3; 1+4; 1+5; 2+3; 3+4; 3+5
Reaction	Points	41.9	41.3	42.7	43.1	41.0	
	Mean time (sec)	0.522	0.521	0.495	0.507	0.544	
T-test (sec)		12.16	12.15	11.78	11.81	12.60	3+5; 4+5
5-0-5 run test (sec)		2.77	2.79	2.75	2.72	2.88	1+5; 3+5; 4+5
Jump without arms swing	Height (cm)	20.6	21.8	24.8	22.3	17.2	1+3; 1+5; 2+5; 3+5; 4+5
	Strength (W/kg)	12.2	13.2	14.9	12.6	11.0	1+3; 2+5; 3+5; 4+5
Jump with arms swing	Height (cm)	26.5	26.7	29.9	28.5	21.8	1+5; 2+5; 3+5; 4+5
	Strength (W/kg)	12.9	14.2	14.5	14.3	11.8	1+5; 3+5; 4+5
Step frequency test	Repetitions	130.6	126.6	133.6	139.4	132.0	
	Right (sec)	0.122	0.134	0.133	0.112	0.137	2+4; 3+4; 4+5
	Left (sec)	0.123	0.133	0.133	0.116	0.134	

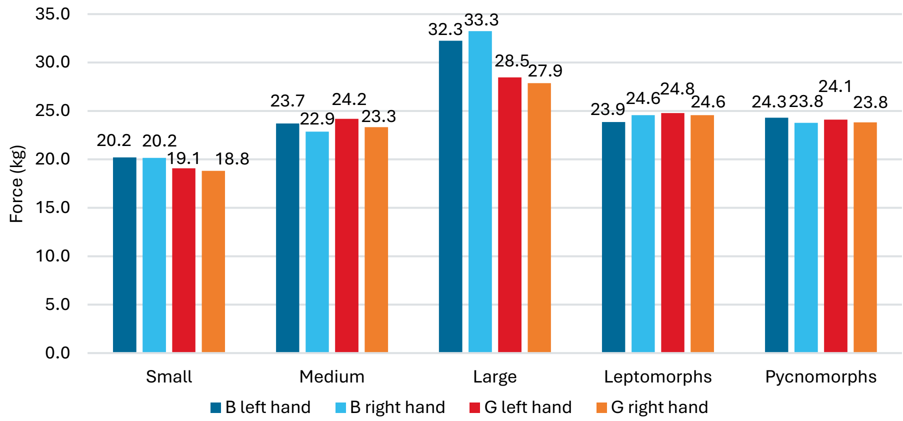

Figure 6. Mean values of hand grip test results in boys (n=86) and girls (n=146) in 5 SD height-weight classes

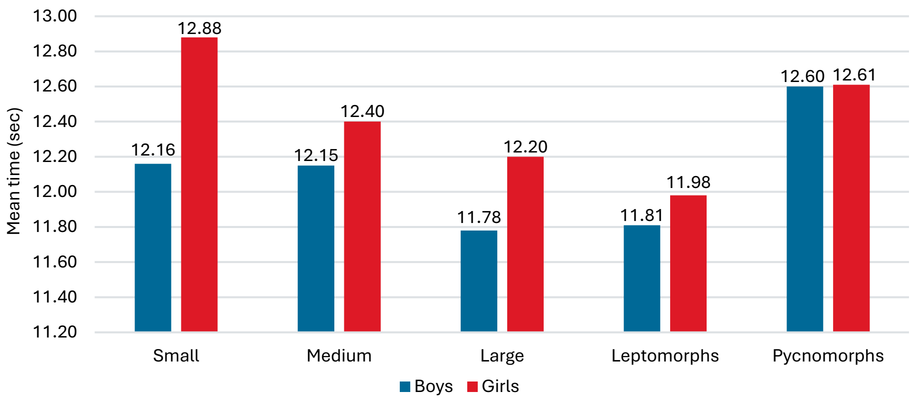

Figure 7. Mean values of speed run T-test results in boys (n=86) and girls (n=146) in 5 SD height-weight classes.

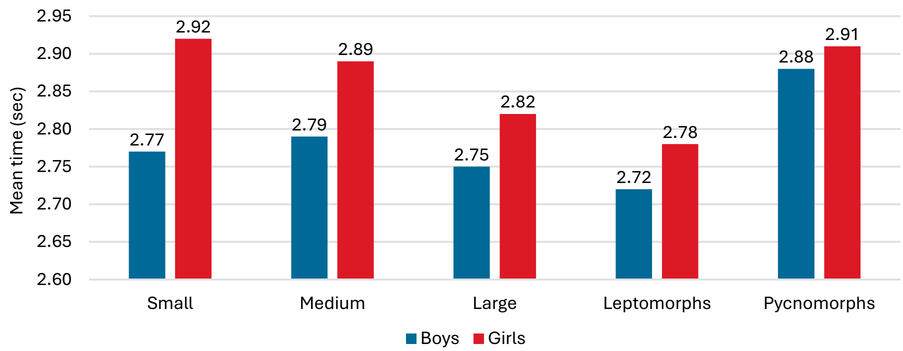

Figure 8. Mean times of boys' (n=86) and girls' (n=146) 5-0-5 run test in 5 SD height-weight classes.

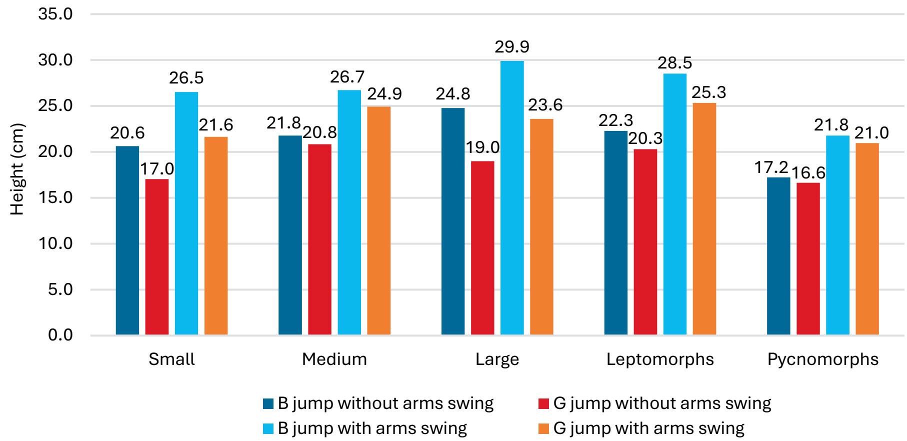

Figure 9. Mean values of jump height without and with arms swing in boys (n=86) and girls (n=146) in 5 SD height-weight classes.

In reaction test in boys, the score of points increased, and the mean time decreased gradually but not statistically significantly from the small to the medium and the large classes. The T-test time decreased gradually in the classes small, medium and large and was better in leptomorphs than in pycnomorphs. There were statistically significant differences between the large class and pycnomorphs and between leptomorphs and pycnomorphs (Figure 7).

The time of the 5-0-5 run test decreased from the small to the large class but not statistically significantly; leptomorphs were faster than pycnomorphs. Considering the mean results, statistically significant differences occurred between classes 1 and 5, 3 and 5, and 4 and 5 (Figure 8). The height of the jump without arms swing increased gradually, and the force applied for it also increased gradually. Jump height without arms swing differed statistically significantly between classes 1 and 3, 1 and 5, 2 and 5, 3 and 5, and 4 and 5. The height of the jump with arms swing increased gradually, and the force applied for it also increased gradually. Jump height was statistically significantly different in classes 1 and 5, 2 and 5, 3 and 5, and 4 and 5; the force applied for this was statistically significantly different in classes 1 and 3, 3 and 5, and 4 and 5 (Figure 9).

The mean time of the reaction test decreased from the small to the medium and the large classes but not statistically significantly and was lower in the class of leptomorphs than in pycnomorphs but not statistically significantly. The number of repetitions in the step frequency test improved in comparison between the small and the large classes but not statistically significantly. The result of leptomorphs was better than that of pycnomorphs but not statistically significantly. The contact time with the ground of both the right and the left foot was the lowest in the small class (Table 6).

Table 7 shows girls' 5 SD height-weight classes – small, medium, large, leptomorphs and pycnomorphs. The mean values of anthropometric variables have been calculated for each class. In all anthropometric characteristics, the values were statistically significantly different in the direction from small to medium and large. Only fat percentage did not differ statistically significantly between the medium and the small classes (Figure 5). Leptomorphs exceeded pycnomorphs in height and arm reach. In all other anthropometric variables, such as weight, BMI, wrist circumference, waist circumference, lower leg circumference, fat percentage and fat amount, pycnomorphs surpassed leptomorphs statistically significantly in the mean results of the classes (Table 7).

Table 8 shows the distribution of girls based on the 5 SD height-weight classification where the mean results of physical ability tests are calculated for each body build class. Hand grip strength with both the left and the right hand increased statistically significantly from the small to the medium and large classes (Figure 6). The mean reaction test time and the score of reaction points improved in the direction from small to medium and large, and leptomorphs were better than pycnomorphs. Statistically significant differences occurred in classes 1 and 2, 1 and 3, and 1 and 4. The results of the running tests (T-test and 5-0-5 run test) improved in the direction from small to medium, large and leptomorphic. Statistically significant differences in the T-test occurred between the classes of small and large, small and leptomorphic, and leptomorphic and pycnomorphic (Figure 7).

Table 7. Distribution of girls based on the 5 SD height-weight classification where the mean values of anthropometric variables and statistically significant differences between classes have been calculated for each body build class (small, medium, large, leptomorphs, pycnomorphs) ($p < 0.05$)

* statistically significant differences between classes are shown in red

Anthropometric variables	Small class (n = 36) mean	Medium class (n = 26) mean	Large class (n = 36) mean	Statistically significant difference between classes 1–3	Leptomo-rph class (n = 30) mean	Pycnomo-rph class (n = 18) mean	Statis-tically significant difference between classes 4–5
Height (cm)	148.76	158.80	168.93	1+2; 2+3; 1+3	164.48	157.36	4+5
Weight (kg)	37.50	49.13	60.85	1+2; 2+3; 1+3	46.47	54.26	4+5
BMI	15.04	17.19	19.56	1+2; 2+3; 1+3	15.77	20.23	4+5
Arm reach (cm)	191.68	204.92	218.69	1+2; 2+3; 1+3	211.75	202.92	4+5
Wrist circumference (cm)	14.15	15.20	15.92	1+2; 2+3; 1+3	14.86	15.74	4+5
Wrist circumference (cm)	61.65	67.04	70.78	1+2; 2+3; 1+3	63.27	71.83	4+5
Lower leg circumference (cm)	20.04	22.37	23.75	1+2; 2+3; 1+3	21.55	22.86	4+5
Fat %	21.47	22.47	24.55	1+3; 2+3	17.57	26.87	4+5
Fat amount (kg)	8.11	11.13	15.23	1+2; 2+3; 1+3	8.18	15.12	4+5

Statistically significant differences in the 5-0-5 run test occurred between classes 1 and 3, 1 and 4, and 4 and 5 (Figure 8). The height of the jump as well as the applied force, both with and without arms swing were better in the medium than in the small class. Statistically significant differences appeared in the jump height without arms swing between classes 1 and 2, 1 and 4, 2 and 5, and 4 and 5, and in jump height with arms swing between classes 1 and 2, 1 and 4, 2 and 5, 3 and 5, and 4 and 5 (Figure 9). In the step frequency test, the step frequency increased in the direction from small to medium and large but not statistically significantly; leptomorphs had a better mean result than pycnomorphs but not statistically significantly. Contact time with the ground in the step frequency test increased in the direction from small to medium but not statistically significantly. In comparison between the classes of leptomorphs and pycnomorphs, leptomorphs outperformed pycnomorphs in the hand grip test with both the right and the left hand; the mean time and the number of points collected in the reaction test were better in leptomorphs than in pycnomorphs. The results of running tests were statistically significantly better in leptomorphs than in pycnomorphs. Leptomorphs had statistically significantly better results in jump height both with and without arms swing than pycnomorphs. In the step frequency test, leptomorphs exceeded pycnomorphs in the number of repetitions, and the contact time with the ground was shorter in leptomorphs than in pycnomorphs but not statistically significantly (Table 8).

Table 8. Distribution of girls based on the 5 SD height-weight classification where the mean results of physical abilities tests and statistically significant differences between classes have been calculated for each body build class (small, medium, large, leptomorphs, pycnomorphs) ($p < 0.05$)

* statistically significant differences between classes are shown in red

Physical abilities indicators		Small class (n = 36) mean	Medium class (n = 26) mean	Large class (n = 36) mean	Lepto-morph class (n = 30) mean	Pycno-morph class (n = 18) mean	Statistically significant difference between classes 1–5
Hand strength (kg)	Left	19.08	24.19	28.47	24.78	24.11	1+2; 1+3; 1+4; 1+5; 2+3; 3+4; 3+5
	Right	18.81	23.23	27.87	24.57	23.83	1+2; 1+3; 1+4; 1+5; 2+3; 3+4; 3+5
Reaction	Points	41.50	43.38	43.83	43.97	42.44	1+2; 1+3; 1+4
	Mean time (sec)	0.53	0.50	0.49	0.49	0.52	1+2; 1+3; 1+4
T-test (sec)		12.88	12.40	12.20	11.98	12.61	1+3; 1+4; 4+5
5-0-5 run test (sec)		2.92	2.89	2.82	2.78	2.91	1+3; 1+4; 4+5
Jump without arms swing	Height (cm)	17.03	20.33	18.99	20.29	16.63	1+2; 1+4; 2+5; 4+5
	Strength (W/kg)	12.60	13.43	13.32	13.39	11.99	
Jump with arms swing	Height (cm)	21.64	24.93	23.59	25.33	20.96	1+2; 1+4; 2+5; 3+5; 4+5
	Strength (W/kg)	12.65	13.72	13.81	13.55	12.08	1+2; 1+3; 2+5; 3+5; 4+5
Step frequency test	Repetitions	127.88	128.73	134.83	134.07	122.33	
	Right (sec)	0.13	0.14	0.13	0.13	0.14	
	Left (sec)	0.13	0.14	0.14	0.13	0.15	

DISCUSSION

A. Abbott and D. Collins [3] have stated that talent identification is the process of finding young people who have greater potential to acquire the top-level abilities necessary to perform a certain activity at the highest level in their chosen sport. National sports federations are often the organizations trying to find young athletes who have a higher potential of success in a certain sport. Also, after finding talents, the aim is to provide additional support and find resources for them to encourage them to continue being engaged in sports in the long term [18].

Considering the above, the Estonian Volleyball Federation has launched the “I am the Future Star” programme in which young volleyball players are measured anthropometrically, and their physical abilities are assessed twice a year. The coaches of national teams and also the coaches of the subjects' own teams are given feedback about players who exceed the mean results of their age group in terms of their physical abilities and body build and have higher than the mean potentiality score.

As early as in 2002, a study of 13–16-year-old volleyball girls revealed that the best jumping ability indicators were in the classes of large and leptomorphic subjects. In the speed test, subjects belonging to the leptomorph class were the fastest and subjects belonging to the pycnomorph class the slowest [22]. The current study revealed that in girls the best results in jumping ability were achieved by leptomorphs and subjects of the medium class. In the speed and agility tests (T-test and 5-0-5 run test), we got the same result that, based on the mean results of the class, the girls of the leptomorphic class were the best, but the girls of the small class got the worst results in this study. From this, it can be concluded that it would be feasible to assess physical abilities based on height-weight classes, as statistically significant differences between body build classes appeared in most of the physical abilities tests selected by us. The girls of the small class were statistically significantly weaker than medium or large girls in hand grip, reaction test points and mean reaction time, T-test and 5-0-5 run and in jumping tests. Only in the step frequency test, there were no statistically significant differences. As regards pycnomorphic and leptomorphic girls, we can see the same tendency – leptomorphs exceeded statistically significantly the results of pycnomorphs and the small class in most tests. The step frequency test was not statistically significantly related to body build, although numerically, the number of repetitions increased in the direction from the small to the medium and the large class, and leptomorphs had better results than pycnomorphs. In the case of boys' physical ability tests results, it is also clear that in most tests there was a statistically significant difference based on the mean results of the class in the direction from small to medium and large. The players of the large class surpassed the players of the small and medium classes in terms of their physical abilities. There were also statistically significant differences between leptomorphs and pycnomorphs, with leptomorphs having statistically significantly better results in physical fitness tests than pycnomorphs. Boys did not have statistically significant differences between the classes in the step frequency test and the reaction test, but considering the mean results of the classes, the same tendency could be observed. Volleyball players of the large class were better than the players of the small or medium class, and leptomorphs outperformed pycnomorphs. Similar results were obtained by M. Aasorg [1], M. Pähn [19], M. Stamm [22] and R. Stamm [23], as they also used the 5 SD height-weight classification in the assessment of physical abilities and anthropometric characteristics and also obtained statistically significant differences between classes in the direction from small to medium and large (large players exceeded the results of the small and medium classes, and the results of pycnomorphs were lower than those of leptomorphs). Moreover, M. Stamm [24] found in his doctoral thesis that the proficiency of volleyball boys was related to body build classes, and boys from the large and the leptomorphic classes were statistically significantly more successful in the game situation.

While studying girls, R. Stamm [23] found in her doctoral thesis that 13-16-year-old volleyball girls also had statistically significant differences in physical ability tests according to the 5 SD body build classes. The girls of the large class outperformed the small and medium ones, and leptomorphs were statistically significantly better than pycnomorphs in both physical abilities and proficiency in the game. R. Stamm [23] also associated individual anthropometric variables with proficiency in the game and found that 13 of the 50 anthropometric variables studied were related to proficiency. Therefore, in this talent identification study, we included 6 of these 13 individual anthropometric variables.

A study conducted in Poland at the FIVB Men's World Championships in 2014 with 24 teams found that 90.36% of the subjects were leptomorphic. The conclusion was reached that leptomorphs are the predominant body build type in elite volleyball [26].

Talents are sought from an early age, starting from nine- and ten-year-olds [4]; therefore, we selected 10-12-year-old volleyball players as the subjects of our study. In a study conducted in Belgium with young female volleyball players where perception and cognitive skills were studied, the subjects were divided into six classes – U9, U11, U13, U15, U17 and older. The results showed that the results improved with increasing age; compared to other age groups, the reaction time in U9, U11 and U13 subjects was slower [8]. Our current study also revealed that the results of the reaction test improved with increasing age (10-year-old girls had an average reaction time of 0.555 sec, 11-year-old girls 0.499 sec, and 12-year-old girls 0.486 sec). Girls' results improved with increasing age in almost all the tests, except for the 5-0-5 run test where 11-year-old and 12-year-old girls had the same mean result (2.8 sec). In boys, the results were similar – as the age increased, the test results also improved.

In Australia, the agility test (T-test) results of talented volleyball players with an average age of 15.5 years improved during an 8-week programme. After the programme, the subjects' mean result was 10.54 sec [10]. In the comparison of means, similar results were also obtained in our present study by 12-year-old boys whose mean T-test result was 11.6 sec.

In a study of volleyball players where main players were compared with reserve players, it was found that an explosive strength test (vertical jump with approach) was a good indicator for distinguishing between the two groups of players [13].

The agility test (T-test) has also been found to be a good indicator for ranking players [12]. Thus, in this study, too, the vertical jump and speed run tests (T-test) were chosen to test physical ability for evaluation of potentiality. Vertical jump is very characteristic of volleyball – 50–60 percent of activities on the volleyball court involve jumping upwards. D. J. Smith et al [21] have said that vertical jump tests are one of the main ways to assess volleyball players' physical abilities.

It is recommended to conduct tests that include movements that are specific to a sport [18]. In the T-test in volleyball, which we used in this study, this is the movement of 9 meters with sidesteps.

Also, the jump without arms swing is related to the blocking technique in volleyball, and the jump with arms swing is related to the technique of spike.

K. Norton et al [16] have suggested that each sport is different and has certain specific requirements for body build, which sometimes have a major role in determining the potential for success in that sport.

L. Massuca and I. Fragoso [15] have also found that, appropriate body build is needed to be successful in volleyball. W. Carvajal et al [6] have found that volleyball players' anthropometric variables are in correlation with the technical and tactical requirements of the game. For predicting the success and potential of young volleyball players, their physiological and anthropometric characteristics are just as important as technical skills [10]. Body height has also been found to be a determining factor for good performance in volleyball and is also often taken into account when looking for potential volleyball players [14]. We also share the opinion that height is one of the most important indicators of success in volleyball. J. M. Palao et al [17] have also found that volleyball players who are taller, weigh more and have a lower body fat percentage are physically more capable in volleyball. Regarding anthropometric measurements in this study, we selected 6 individual anthropometric variables for measurement, which were 2 length measurements (height and arm reach), weight, three circumferences (wrist, lower leg and waist circumference) and two fat indicators (fat percentage and fat amount). From weight and height, we calculated BMI and 5 SD height-weight classes, which made it possible to assess the player's body build as a whole. Based on the results we obtained, it is interesting to point out that all other individual anthropometric characteristics besides height and weight behaved as expected, increasing gradually from the small to the medium and the large class. Circumferences were smaller in in the class of leptomorphs than in the class of pycnomorphs, and length measurements were larger in in the class of leptomorphs than in the class of pycnomorphs. It is also very interesting to note that body build and physical abilities were so strongly related; there were statistically significant differences between body build classes in nearly all the tests of physical abilities and reaction speed. Only the results of the step frequency test did not differ statistically significantly in different body build classes, except for one indicator in boys. Still, both boys' and girls' results in the step frequency test (similarly to other tests) improved in the direction from small to medium and large, and leptomorphs were better than pycnomorphs.

Prominent talent means clearly above average sports skills compared to others of the same age as well as the potential to be successful at a higher level of competition [4]. Therefore, we also compared the results of our students with the average result of the student's age group and considered just those students who exceeded the average result of their age group in each physical ability test the most promising.

D. J. Burgess and G. A. Naughton [5] have said that, despite its complexity, talent development is a worthwhile investment in professional team sports.

For Estonia to be successful compared to other countries in a sport like volleyball, we need to find and develop and direct our resources to the search and development of young talents, because with such a small population, we should not overlook any young potential national team player.

CONCLUSION

Based on a 5 SD height-weight classification, we established young volleyball players' body build types and found statistically significant differences between body build types in anthropometric variables and in physical ability tests and in the reaction test. Data analysis revealed that both boys' and girls' physical ability tests results improved from the small to the medium and large classes, and the results of leptomorphs were better than those of pycnomorphs, and most differences were statistically significant.

We identified the volleyball players who exceeded the average results of their age groups in terms of their individual results and gave a potentiality score for height, arm reach, wrist circumference, lower leg circumference and all physical ability tests and the reaction test if they exceeded the average result of their age group. Another scoring point was added if the player belonged to the large or leptomorphic 5 SD height-weight class. By adding the score points obtained for different tests, we got the summary potentiality score. Volleyball players whose score exceeded the mean score of points in their age group were considered more promising in each age group. Thus, we managed to identify the most talented players whose development should be followed and supported. We hope that they will become efficient players to represent Estonia in the youth teams of different age groups and, in the future, in the national team of adults.

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