BASIC ANTHROPOMETRIC MEASUREMENTS AND PROFICIENCY IN THE GAME OF ADOLESCENT (UP TO 16-YEAR-OLD) MALE VOLLEYBALLERS AT ESTONIAN CHAMPIONSHIPS IN THREE DIFFERENT YEARS

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ABSTRACT

The article analyses young male volleyballers' age, body build and performance at Estonian championships for up to 16-year-olds at three tournaments – Tartu 2005, Viljandi 2006 and Rakvere 2008. In all these years, the participants were the eight best teams of Estonia at the moment. A total of 197 boys were studied; 13 body measurements were taken. Proficiency in the game was assessed for both teams in parallel with two computers provided with the program *Game*.

Thirty-one indicators of proficiency in the game were calculated at each tournament. When we compared the tournament of 2005 with the tournament of 2008, we found statistically significant differences in nine indicators. The quality of the games has improved and the teams have become more equally matched. The number of spikes and blocks has increased; the indices of proficiency for all technical elements were higher in 2008 than in 2005. It is interesting that serve has changed from an element of putting the ball into the game into a genuinely attacking element. The number of ace serves has increased statistically significantly; the proficiency index of serves has rose by 2008. Unfortunately, however, the height and weight of the players decreased by 2008. This is a cause for concern, as taller players are more successful in volleyball.

Keywords: *volleyball, adolescent, anthropometry, game statistics, index of proficiency, performance*

INTRODUCTION

The article analyses the proficiency in the game at Estonian championships for male volleyballers aged up to 16 years and assesses their body build based on 13 basic measurements in 2005, 2006 and 2008. It is a cross-sectional study that shows how the quality of the game and the body build indicators in this age group have changed over four years.

MATERIAL AND METHODS

The sample consisted of 197 boys aged 13–15 years from 24 most successful volleyball teams of up to 16 year olds who participated in Estonian championships in Tartu in 2005, in Viljandi in 2005 and in Rakvere in 2008.

Anthropometric variables

During the intervals between the matches, all the 197 boys were measured anthropometrically using the method of Martin [4]. Thirteen body measurements were taken that in the present authors' earlier studies [7, 8] had shown significant correlation with proficiency in the game. These measurements were height, weight, suprasternal height, xiphoidal height, wrist breadth, chest circumference, waist circumference, hip circumference, upper thigh circumference, lower leg circumference, arm circumference, flexed and tensed arm circumference, and wrist circumference.

Assessment of players' proficiency

To record the games, an original computer program *Game* was used, which was first presented by R. Nõlvak (Stamm) in 1995. The methodology of the program has been introduced in a specialist journal in the USA [6].

The assessment of players' proficiency proceeded as follows: during the match, the expert registered, using the program *Game*, each case when a player performed a technical element (serve, reception, block, spike). This was done by pressing three keys on the keyboard: (1) which element was performed, (2) how it was performed (the grade for the performance on a five-point scale – 1 excellent, 5 fault), (3) the number of the player who performed the element.

For all the elements, the program calculates each player's index of proficiency according to the following formula:

$$\text{Index of proficiency} = \frac{\text{number of performances} \times \text{maximum grade} - \text{sum of grades}}{(\text{maximum grade} - 1) \times \text{number of performances}}$$

In addition to the index of proficiency, the program calculates the following data for each set and for the whole match: the number of all technical elements for each player and for the whole team, average indices of proficiency of each element for each player and for the whole team, points scored by performing the elements. A separate count was kept on the total number of successfully performed elements and their average number per game. The number of errors while performing each element and the average number of errors per game were also calculated. A total of 31 variables were calculated to evaluate the proficiency of the players.

The total number of games recorded in Tartu in 2005 was 28, in Viljandi in 2006 – 19, and in Rakvere in 2008 – 28.

Statistical analysis

The data were analysed using the SAS system. Means and standard deviations of anthropometric measurements for each tournament and separately for each age group (13–15) were calculated and the variables' correlations with age were found (Tables 1, 2, 3).

Using the data on elements performed by individual players, the statistical section of the program *Game* computed the players' and the whole team's essential technical data for a particular set and for the whole game – the total number of elements performed and the number of points gained.

Statistical analysis of the data was continued after the championships, using the SAS system, in order to compare the technical data of different tournaments. For this purpose, primary statistical analysis of each tournaments' technical data was performed where their mean and SD were computed, and the significance of the differences between the results of the first (2005) and the last (2008) tournaments were checked by the t-test (Table 4).

RESULTS

We present the results of volleyballers' anthropometric measuring at three Estonian championships for boys aged up to 16 years (Tartu 2005, Viljandi 2006, Rakvere 2008). Tables 1, 2 and 3 present the values of 13 body measurements of players who participated in the championships separately according to age groups – the means and standard deviations of the boys aged 13, 14 and 15 years. Table 1 describes the boys who participated in the tournament in Tartu in 2005, Table 2 – the boys who participated in the tournament in Viljandi in 2006 and Table 3 – in Rakvere in 2008. The players' mean height was the highest (175.89 cm, SD=8.4) in Viljandi in 2006 and the lowest (173.25 cm, SD=9.8) in

Rakvere in 2008. The data of weight were similar, their mean being the smallest at the third tournament (60.41 kg, SD=9.9), while in the first two tournaments the boys' mean weight was respectively 62.2 kg (SD=10.0) and 62.3 kg (SD=9.8). From the viewpoint of proficiency in volleyball, we would have liked to see an increase in the players' mean height and weight by 2008 compared to 2005 and 2006. Then we would have been able to state that volleyball coaches apply the principle of talent scouting when composing training groups, as taller players are more successful in volleyball.

The last columns of Tables 1, 2, 3 show the relations of the players' anthropometric variables with age. Practically all the body measurements correlate with age; correlation strength r=0.2–0.6. This is quite logical, as 13-year-olds are somewhat shorter and lighter than 14- and 15-year-olds. Such a tendency is characteristic of all the three years of the study.

Table 4 presents the data on the boys' proficiency in the game at all the three tournaments according to 31 variables of proficiency. The mean results of proficiency in 2005 and 2008 have been compared statistically.

The comparison of the proficiency in the game at the tournaments of 2005 and 2008 reveals that the proficiency of performance of technical elements by players was higher in the last tournament (Rakvere 2008) compared to the first one (Tartu 2005).

The mean proficiency of serve in 2005 was 0.38 (SD=0.1) and in 2008 0.45 (SD=0.07). The mean proficiency of reception was 0.52 at the first tournament and 0.54 at the last one (SD 0.19 and 0.1 respectively); the mean proficiency of block 0.36 at the first tournament and 0.44 at the last one (SD 0.24 and 0.25) and the mean proficiency of spike 0.54 and 0.58 (SD 0.19 and 0.18). Still, a statistically significant difference in the proficiency indices of elements appeared only in the proficiency of serve (Table 4).

There were also other statistically significant differences in the elements of the game. As the Table shows, there are statistically significant differences in (1) total number of serves, (3) total number of ace serves, (4) mean number of ace serves, (10) mean number of reception errors, (13) total number of blocks, (17) total number of block errors and (18) mean number of block errors per game. In those cases, too, the results were higher at the third tournament in Rakvere.

Table 4 also enables us to see changes in the quality of games of up to 16-year-old male volleyballers. As the cohort who participated in the Estonian championships in 2005 is not the same as at the championships of 2008, we cannot assess the players' individual development. Nonetheless, we can see if the same age group three years later plays volleyball with the same proficiency or the performance of some elements has improved or deteriorated. We can

compare whether the players make more or fewer of their own errors that result in the opponent gaining a point. The analysis of serve shows that, while in 2005 the serve was mainly an element used for putting the ball into the game, by 2008 it had become a genuine element of attack. The mean index of proficiency of serve has increased through the years from 0.38 to 0.41 and 0.45; the respective standard deviations being 0.1, 0.1 and 0.07. While at the Estonian championships of 2005, 278 points were gained by ace serves (SD=4.26), in 2008 their number was 309 already (SD=4.18). The difference was statistically significant. Simultaneously, the number of errors at serve diminished – from 308 errors in 2005 (SD=4.3) to 204 errors in 2008 (SD=3.7).

Reception of serve has become weaker. This is shown by a statistically significant indicator – reception errors during the tournament. In 2005, the number of errors was 272 (SD=3.65), in 2008 – 292 (SD=4.2). The mean number of reception errors per person in a game has also increased statistically significantly – from 0.65 (SD=0.58) in 2005 to 0.75 (SD=0.62) in 2008. It is very interesting that the mean index of proficiency for reception has nonetheless somewhat improved – from 0.52 (SD=0.19) in 2005 to 0.54 (SD=0.1) in 2008. The difference between the two tournaments, however, is not statistically significant. This contradiction can be explained by the fact that, although the number of reception errors increased, the number of successful receptions was also greater in 2008 than in 2005.

The total number of blocks was 938 in 2005 and 1057 in 2008. The difference between these variables is statistically significant, and it is a good indicator in the game of young players that the total number of blocks has increased. In 2005 the mean number of successful blocks per game was 3.81 (SD=5.01), in 2008, however, 4.75 (SD=5.19). At the same time, the mean number of blocking errors per game has also increased statistically significantly from 4.25 (SD=4.33) in 2005 to 6.85 (SD=5.76). As we can see from the proficiency index of block, the proficiency of blocking has still somewhat improved. As the difference between the indices of proficiency is not statistically significant (0.36 in 2005 and 0.44 in 2008), we can say that there exists a tendency towards improvement in blocking.

As for attacks, in the 28 championship games of 2005, 2986 attacks were performed and in the 28 games of 2008 – 3256 attacks. The total number of attacks has increased, and the total number of successful attacks also increased by 55 by 2008 (Table 4). The value of the proficiency index also increased by 2008. However, as there is no statistically significant difference between the indicators of attack, we can state, similarly to block, that there exists a tendency towards improvement of the proficiency of attack.

Table 1. Means and standard deviations of basic anthropometric measurements in age groups of young male volleyballers (n=67) and their correlations with age. Estonian championship for 13-15-year-old boys in 2005 in Tartu

No	Variable	All n=67		13 years n=5		14 years n=15		15 years n=47		Statistically significant correlation with age (p)
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
1	Height (cm)	175.381	8.981	167.160	11.434	170.653	9.096	177.474	7.602	**0.404 (<0.001)**
2	Weight (kg)	62.219	10.020	53.500	9.859	54.540	8.356	65.272	8.471	**0.487 (<0.001)**
3	Suprasternal height (cm)	143.581	7.795	135.980	9.452	139.180	8.702	145.538	6.167	**0.433 (<0.001)**
4	Xiphoidal height (cm)	125.679	6.712	119.900	8.110	122.740	7.351	126.989	5.694	**0.359 (0.003)**
5	Chest circumference (cm)	85.576	6.063	80.900	6.414	80.620	5.250	87.562	5.171	**0.477 (<0.0001)**
6	Waist circumference (cm)	72.974	4.611	70.800	5.974	69.740	4.484	74.128	3.986	**0.361 (0.003)**
7	Hip circumference (cm)	91.679	6.056	87.460	7.076	87.033	6.218	93.428	4.856	**0.439 (<0.001)**
8	Arm circumference (cm)	26.672	2.624	25.500	2.973	24.507	2.413	27.413	2.231	**0.399 (<0.001)**
9	Arm circumference flexed and tensed (cm)	28.864	2.693	27.430	3.205	26.580	2.136	29.668	2.326	**0.429 (<0.001)**
10	Wrist circumference (cm)	17393	0.931	17.000	1.098	16.733	0.730	17.628	0.876	**0.352 (0.0035)**
11	Upper leg circumference (cm)	53.397	6.037	50.940	4.668	50.573	5.286	54.366	6.055	**0.258 (0.035)**
12	Lower leg circumference (cm)	23.568	1.594	22.320	1.026	22.493	1.589	24.009	1.428	**0.426 (<0.001)**
13	Wrist breadth (cm)	5.978	0.389	5.700	0.543	5.840	0.327	6.040	0.371	**0.292 (0.0163)**

Table 2. Means and standard deviations of basic anthropometric measurements in age groups of young male volleyballers (n=67) and their correlations with age. Estonian championship for 13–15-year-old boys in 2006 in Viljandi

No	Variable	All n=67		13 years n=6		14 years n=20		15 years n=41		Statistically significant correlation with age (p)
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
1	Height (cm)	175.887	8.444	159.733	2.930	175.855	6.823	178.266	7.036	**0.529 (<0.001)**
2	Weight (kg)	62.340	9.776	49.667	6.651	61.345	7.564	64.680	9.735	**0.404 (<0.001)**
3	Suprasternal height (cm)	143.651	7.251	129.050	2.085	143.560	5.564	145.832	5.887	**0.561 (<0.001)**
4	Xiphoidal height (cm)	125.788	6.733	113.683	1.664	125.090	6.045	127.900	5.504	**0.543 (<0.001)**
5	Chest circumference (cm)	85.542	6.454	78.800	6.230	83.970	5.027	87.295	6.378	**0.399 (<0.001)**
6	Waist circumference (cm)	73.491	5.804	69.100	5.170	72.525	4.256	74.605	6.246	**0.285 (0.019)**
7	Hip circumference (cm)	91.066	6.411	84.800	7.298	90.835	4.827	92.095	6.565	**0.286 (0.019)**
8	Arm circumference (cm)	26.394	2.586	24.300	2.093	26.090	2.225	26.849	2.687	**0.277 (0.023)**
9	Arm circumference flexed and tensed (cm)	28.667	2.439	26.183	1.873	28.405	2.413	29.159	2.325	**0.330 (0.006)**
10	Wrist circumference (cm)	16.949	1.004	16.167	1.097	16.925	1.001	17.076	0.964	
11	Upper leg circumference (cm)	54.148	5.432	51.233	5.083	53.665	4.610	54.810	5.791	
12	Lower leg circumference (cm)	23.848	1.502	23.400	1.359	23.755	1.463	23.959	1.558	
13	Wrist breadth (cm)	5.942	0.346	5.467	0.175	5.940	0.314	6.012	0.329	**0.381 (0.002)**

Table 3. Means and standard deviations of basic anthropometric measurements in age groups of young male volleyballers (n=67) and their correlations with age. Estonian championship for 13-15-year-old boys in 2008 in Rakvere

No	Variable	All n=63		13 years n=12		14 years n=14		15 years n=37		Statistically significant correlation with age (p)
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
1	Height (cm)	173.252	9.852	160.417	8.561	172.557	8.168	177.678	6.742	**0.655 (<0.001)**
2	Weight (kg)	60.413	9.575	49.592	11.135	60.614	6.419	63.846	7.347	**0.545 (<0.001)**
3	Suprasternal height (cm)	141.419	8.865	130.217	7.824	140.686	7.200	145.330	6.337	**0.640 (<0.001)**
4	Xiphoidal height (cm)	123.752	8.015	113.892	6.902	122.821	6.895	127.303	5.763	**0.633 (<0.001)**
5	Chest circumference (cm)	84.181	6.674	77.625	8.025	82.157	6.137	86.695	4.712	**0.523 (<0.001)**
6	Waist circumference (cm)	72.151	5.475	68.117	6.912	72.521	5.504	73.319	4.382	**0.340 (0.006)**
7	Hip circumference (cm)	90.016	6.511	82.458	7.354	90.593	4.746	92.249	4.905	**0.541 (<0.001)**
8	Arm circumference (cm)	26.116	2.343	24.517	2.882	26.421	2.322	26.519	1.978	**0.296 (0.019)**
9	Arm circumference flexed and tensed (cm)	28.195	2.580	26.075	2.844	28.443	2.384	28.789	2.248	**0.373 (0.003)**
10	Wrist circumference (cm)	17.203	1.018	16.258	0.935	17.307	0.875	17.470	0.931	**0.424 (<0.001)**
11	Upper leg circumference (cm)	53.292	4.503	50.367	5.309	53.986	4.814	53.978	3.797	**0.273 (0.030)**
12	Lower leg circumference (cm)	23.717	1.577	22.867	2.061	23.750	1.672	23.981	1.289	**0.257 (0.042)**
13	Wrist breadth (cm)	5.917	0.350	5.600	0.234	5.879	0.383	6.035	0.305	**0.474 (<0.001)**

Table 4. Adolescent male volleyballers' game proficiency in Estonian championships in 2005, 2006 and 2008

No	Variable	2005						2006						2008						Statistically significant correlation between mean values of 2005 and 2008 (α=0,05)
		No	Min	Max	Mean	SD	Sum	No	Min	Max	Mean	SD	Sum	No	Min	Max	Mean	SD	Sum	
1	Serves – total	68	0,00	77,00	37,91	21,42	2578,00	60	2,00	69,00	28,67	17,29	1720,00	52	2,00	75,00	49,85	14,72	2592,00	+
2	Serves – average per game	68	0,33	10,57	6,70	3,67	455,34	60	0,50	10,80	6,55	2,61	392,79	52	0,00	10,71	7,14	2,09	371,42	
3	Successful serves – total	68	0,00	19,00	4,09	4,26	278,00	60	0,00	16,00	3,40	4,09	204,00	52	0,00	20,00	5,94	4,18	309,00	+
4	Successful serves – average per game	68	0,00	2,71	0,62	0,62	42,48	60	0,00	3,20	0,75	0,77	44,79	52	0,00	2,86	0,86	0,61	44,73	+
5	Serve errors – total	68	0,00	17,00	4,53	4,30	308,00	60	0,00	11,00	3,28	2,95	197,00	52	0,00	18,00	4,73	3,71	246,00	
6	Serve errors – average per game	68	0,00	2,43	0,68	0,62	46,39	60	0,00	3,00	0,76	0,58	45,48	52	0,00	2,57	0,68	0,53	35,23	
7	Index of proficiency at serve	68	0,00	0,67	0,38	0,10	25,87	60	0,23	0,75	0,41	0,10	24,76	52	0,28	0,75	0,45	0,07	23,29	+
8	Receptions – total	68	0,00	127,00	33,51	30,52	2279,00	60	1,00	82,00	25,39	18,44	1498,00	59	1,00	141,00	40,12	36,40	2367,00	
9	Receptions – average per game	68	0,20	18,14	5,84	5,28	397,36	60	0,50	17,67	5,75	3,75	339,17	59	0,33	20,14	5,94	5,05	350,25	
10	Reception errors – total	68	0,00	12,00	4,00	3,65	272,00	60	0,00	11,00	3,34	2,70	197,00	59	0,00	16,00	4,95	4,24	292,00	+
11	Reception errors – average per game	68	0,00	2,00	0,65	0,58	44,18	60	0,00	3,33	0,81	0,65	47,56	59	0,00	2,29	0,75	0,62	44,02	+
12	Index of proficiency at receptions	68	0,00	1,00	0,52	0,19	35,69	60	0,00	0,74	0,52	0,13	30,39	59	0,32	0,73	0,54	0,10	31,64	
13	Blocks – total	48	0,00	56,00	13,79	14,75	938,00	48	1,00	51,00	11,46	9,54	550,00	53	1,00	60,00	19,94	17,08	1057,00	+
14	Blocks – average per game	68	0,00	6,43	2,53	1,91	171,95	48	0,20	7,29	2,51	1,66	120,33	53	0,14	8,57	2,91	2,38	154,21	

No	Variable	2005						2006						2008						Statistically significant correlation between mean values of 2005 and 2008 (α=0,05)
		No	Min	Max	Mean	SD	Sum	No	Min	Max	Mean	SD	Sum	No	Min	Max	Mean	SD	Sum	
15	Successful blocks – total	68	0,00	19,00	3,81	5,01	259,00	48	0,00	21,00	3,65	3,87	175,00	53	0,00	20,00	4,75	5,19	252,00	
16	Successful blocks – average per game	68	0,00	4,50	0,60	0,85	41,12	48	0,00	3,00	0,74	0,66	35,61	53	0,00	2,86	0,69	0,74	36,49	
17	Block errors – total	68	0,00	14,00	4,25	4,33	289,00	48	0,00	10,00	3,06	2,35	147,00	53	0,00	26,00	6,85	5,76	363,00	+
18	Block errors – average per game	68	0,00	4,00	0,68	0,74	46,22	48	0,00	2,00	0,71	0,48	33,86	53	0,00	3,71	1,02	0,80	53,86	+
19	Index of proficiency at block	68	0,00	0,75	0,36	0,24	24,68	48	0,00	1,00	0,50	0,17	23,98	53	0,00	1,48	0,44	0,25	23,08	
20	Spikes – total	68	0,00	222,00	43,91	49,36	2986,00	58	1,00	186,00	37,17	35,14	2156,00	57	1,00	243,00	57,12	58,96	3256,00	
21	Spikes – average per game	68	0,00	31,71	3,75	4,93	255,00	58	0,25	28,00	8,21	6,75	475,95	57	0,20	34,71	8,23	8,36	469,02	
22	Successful spikes – total	68	0,00	120,00	17,96	24,25	1221,00	58	0,00	77,00	12,90	14,58	748,00	57	0,00	116,00	22,39	25,33	1276,00	
23	Successful spikes – average per game	68	0,00	17,14	2,71	3,50	184,13	58	0,00	11,00	2,76	2,66	160,33	57	0,00	16,57	3,22	3,60	183,77	
24	Spike errors – total	68	0,00	34,00	8,32	9,11	566,00	58	0,00	22,00	6,57	5,87	381,00	57	0,00	44,00	9,68	10,15	552,00	
25	Spike errors – average per game	68	0,00	5,20	1,29	1,37	87,47	58	0,00	5,67	1,47	1,25	85,36	57	0,00	6,29	1,40	1,44	79,76	
26	Index of proficiency at spike	68	0,00	1,00	0,54	0,19	36,81	58	0,00	0,88	0,54	0,17	31,13	57	0,00	1,00	0,58	0,18	33,00	
27	Points won – total	68	0,00	149,00	25,93	31,79	1763,00	64	0,00	109,00	17,73	20,10	1135,00	63	0,00	156,00	29,13	31,89	1835,00	
28	Points won – average per game	68	0,00	21,29	3,90	4,55	265,23	64	0,00	15,57	3,81	3,52	239,95	63	0,00	22,29	4,20	4,52	264,85	
29	Points errors – total	68	0,00	76,00	32,34	21,53	2199,00	64	0,00	52,00	20,22	13,67	1273,78	63	1,00	96,00	38,25	24,24	2410,00	
30	Points errors – average per game	68	0,00	12,60	5,05	2,91	343,69	64	0,00	11,33	4,74	2,61	298,74	63	0,50	13,71	5,70	3,19	359,14	

DISCUSSION

We analysed boys' basic anthropometric characteristics and their proficiency in the game during three Estonian championships for the U-16 age group in 2005, 2006 and 2008. Statistical significance of differences was checked between the results of 2005 and 2008. The boys' mean body build data showed that the players of 2008 were shorter and lighter. Although there were more 13-year-olds among the players at the last tournament, the mean height and weight of boys aged 14 and 15 years had also decreased as compared to the boys of the same age in 2006. This, unfortunately, is a cause for concern, as taller players are more successful in volleyball. Literature includes many references to that [1, 2, 3, 5, 9]. Unfortunately, the Estonian coaches have not been able to find taller and more promising young players for their teams in this age group.

The play of young players had also become more equal by 2008, as the total number of blocks and attacks had increased, that of blocks – statistically significantly. The quality of games had also improved during the four years. The proficiency of serve increased statistically significantly. Serve had become a really attacking element in the games of young boys. The values of all the other indices of proficiency also increased from the first to the last tournament, but the difference was not big enough to be statistically significant. Thus, we can state that our data revealed a tendency towards improvement of block, spike and reception of serve.

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