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SYSTEM FOR CONTROL, EVALUATION AND VISUALIZATION OF THE PHYSICAL DEVELOPMENT OF YOUNG MALE TAEKWONDO ATHLETES

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ABSTRACT
PURPOSE: The purpose of this study is to create a normative tables for control and evaluation of the physical development in taekwondo according to the age groups of the World Taekwondo Federation. METHODS: Seven standard physical tests were used to measure the physical development of 208 male taekwondo athletes. The tests we used were: 1. Stand and reach, 2. Split, 3. Modified T- test, 4. Vertical jump, 5. Push-ups – 30 seconds, 6. Sit-ups – 30 seconds, 7. Squat jumps – 30 seconds. The method of Sigma digressions was used for creating the ranking scales. RESULTS: On the basis of our results specific tables were designed for each test and age group with the use of a 7, 20 and 50-grade (point) scale. The input and visualization were automated into a graphic file for easier comprehension. CONCLUSIONS: The results of our study are a starting point for creating a database for taekwondo. They can also serve as a basis for overall evaluation system of taekwondo athletes. Such a system will provide a crucial feedback about the efficiency of the training methods, the current physical condition of the athletes and will be of motivational use for taekwondo practitioners.

Key words: taekwondo, control, test, physical development

INTRODUCTION

Taekwondo is a Korean martial art renowned for its dynamic kicks and powerful techniques. It is also an official Olympic sport since the Games in Sydney in 2000. As in most sports, physical conditioning is a cornerstone for Taekwondo, ensuring that practitioners possess the strength, agility, endurance, and flexibility required to execute moves effectively. Physical tests in Taekwondo are designed to assess and enhance these attributes, playing a vital role in a practitioner's development and progression through the ranks.

The performance of systematic research and control of sports competition activity is imperative for a well-programmed and managed training process (1), with the quality selection of sports talents being one of the key factors of the system of the adolescent sport (2).

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There are no clearly established normativecharts and requirements for introduced control of the organized educational and training process when working with young competitors and practitioners of taekwondo in Bulgaria and in the world. The lack of a comprehensive approach and an up-to-date system for controlling the sports training of young taekwondo athletes is a major problem in carrying out not only the selection for competition, but also the control of sports training in general (1). The introduction of a test battery will be useful and would greatly facilitate the work of coaches in terms of optimizing the training process.

Fukuda (2) states that one of the difficulties when working with individuals or small groups of clients or athletes is the pitfall of potentially viewing their abilities in a vacuum without comparison to others. This can lead to complacency or a lack of focus on fundamental skills and physical capacities.

Although testing of the physical abilities of taekwondo athletes has been done before (4, 5), it has never been systemized and more

importantly, it has never been transferred to normative data for taekwondo. The tests used for measuring general physical qualities in taekwondo so far, are as follows:

Table 1. *Tests, used for assesment of taekwondo athletes' motor abilities (2)*

MOTOR ABILITY	TEST	AUTHORS
POWER	Cord-based jump meter	Cetin et al. (5)
	Electronic jump mat	Markovic et al. (6)
	Force platform	Heller et al. (7)
	Jump and reach	Toskovic et al. (8), Erie and Pieter (9), Noorul et al. (10), Suzana and Pieter (11)
	Optical acquisition system	Chiodo et al. (12), Ball et al. (13), Casolino et al. (14)
MAXIMAL DYNAMIC STRENGTH	Bench press	Toskovic et al. (8), Markovic et al. (6)
	Leg press	Toskovic et al. (8)
	Back squat	Markovic et al. (6)
MUSCULAR ENDURANCE	Sit-ups: 60 s test	Thompson and Vinueza (15), Toskovic et al. (8), Markovic et al. (6),
	Push-ups: 60 s test	Markovic et al. (5)
FLEXIBILITY	Sit-and-reach	Thompson and Vinueza (15), Toskovic et al. (8), Heller et al. (7), Rivera et al. (16), Suzana and Pieter (11), Markovic et al. (6),
MAXIMUM OXIGEN UPTAKE (AEROBIC ENDURANCE)	Treadmill	Taaffe and Pieter (17), Thompson and Vinueza (15), Chiodo et al. (18), Rivera et al. (16), Cubrilo et al. (19), Markovic et al. (6), Lee et al. (20)
ANAEROBIC ENDURANCE	Cycle ergometer	Heller et al. (7)
	Shuttle run test	Ball et al. (13), Bouhlel et al. (21), Erie and Pieter (9), Butios and Tasika (22), Perez-Gomez et al. (23), Perandini et al. (24), Noorul et al. (10)
	30 s Wingate test	Taaffe and Pieter (25), Bercades et al. (26), Perez-Gomez et al. (23), Heller et al. (7)
	7 s force-velocity test (incremental breaking forces)	Perez-Gomez et al. (23), Lin et al. (27)

However, all of these results have never been systemized and neither has a normative data for Taekwondo been developed.

METHODS

The purpose of the study is to create a system for tracing the improvement and evaluation of the motor abilities of young male Taekwondo athletes. The main tasks of the research were:

1. To select suitable tests for evaluation of the dominant physical qualities in Taekwondo
2. To carry out testing with the selected groups – 4-6, 7-9, 10-11, 12-14 years old.
3. To design a 7, 20 and 50-grade normative scale for evaluation of the tested motor abilities.
4. To create a user friendly visualization of the results and progress of the athletes.

Participants

The research was done among 208 male taekwondo athletes, aged 4-14 years, members of the "Taekwondo Fitness NSA" sport club. They were divided according to the age groups for competition according to the World Taekwondo Federation (28) as follows: "Baby"- age 4 – 6 years old, "Children I" – age

7 - 9 years old, "Children II" – age 10 - 11 years old, "Cadets" – 12 – 14 years old. All the study procedures were in accordance with the Declaration of Helsinki. Prior to the study, parental agreement was obtained for all tested children.

Test procedures

The athletes were tested in 4 days. All of the athletes performed a 20 minute warm up, including 5 minute run and standard stretching exercises. Following that, each one of the subjects performed the tests following this set: 1. Stand and reach, 2. Split, 3. T-test, 4. Vertical jump, 5. Push-ups – 30 seconds, 6. Sit-ups – 30 seconds, 7. Squat jumps – 30 seconds.

Statistical processing

The mathematical and statistical methods used in this study were descriptive statistics and comparative analysis. All statistical procedures were performed using SPSS Statistics v.19 (IBM, Chicago, Illinois, USA).

In order to design the normative tables, we used the method of the sigma digressions. According to this method for evaluation of the condition of the researched subjects, the evaluated index is compared with the average level of the same index. The main characteristics used are mean arithmetical value and standard deviation (27). We developed a 7 grade and a 50 grade point scales since further investigation is needed to verify their effectiveness in taekwondo.

Sport-pedagogical testing:

Test 1: Stand and reach

The athlete stands with hands up on a gymnastic bench (feet together with toes to the edge of the bench) and performs a maximum lean with the body forward and down. During the leaning, the knees are straight and the arms are extended towards the floor. The lowest position of the leaning is held 3 seconds. The distance between the upper edge of the gymnastic bench below the feet and the fingers is recorded. The athlete makes three attempts and the greatest one is recorded.

Figure 1. Stand and reach test

Test 2: Side Split

The split is performed in a straight line (pelvis and ankles are on the same line). The pelvis should be against the wall. The distance between the floor and the lowest part of the pelvis is measured using a tape measure. The test is performed on an elevated surface for the feet, so the result can be measured if the tested subject could perform beyond the full split.

Figure 2. Side Split test

Test 3: Three-cone drill

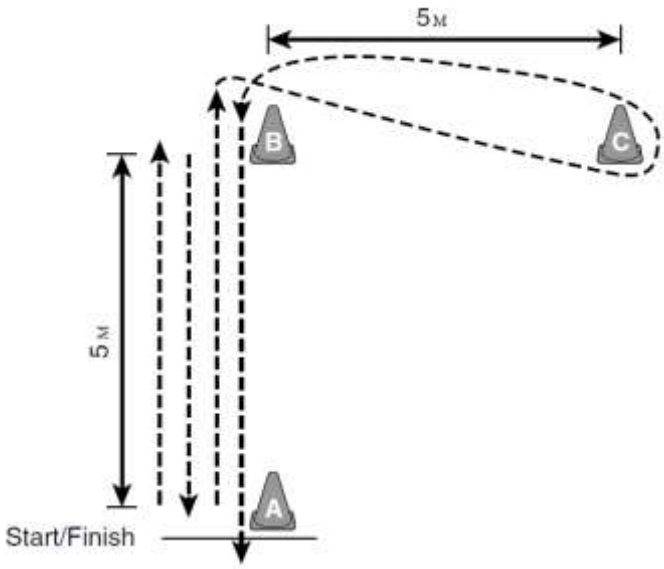

Figure 3. Three-cone drill

After a signal. the athlete follows the path of the arrows on the figure and finishes the distance. The time of the course is measured with a timing device.

Test 4: Vertical jump

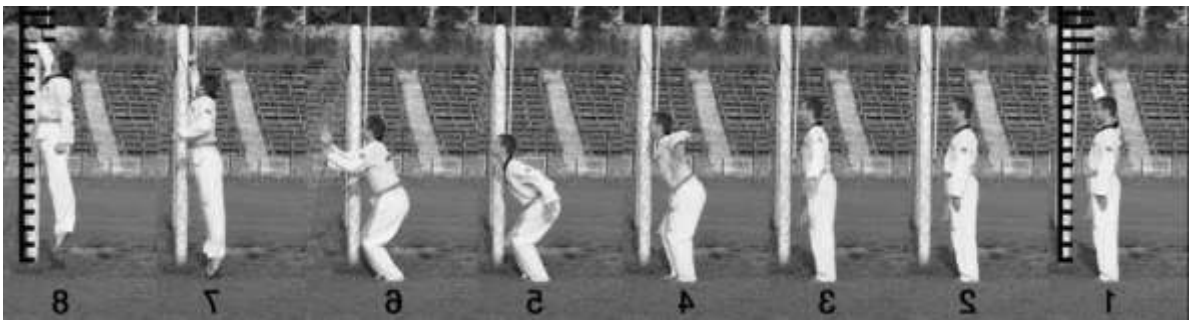

Figure 4. Vertical jump test

The measured person stands sideways to the scale with his hand raised, marking the end of his fingers (position 1). The fingers are smeared with talc or magnesium and a vertical jump is performed such that at its highest point (position 8), the subject touches the scale with his hand. 3 attempts are performed, and the best result is taken. The end result is the difference in centimeters between the "standing" mark and the one during the jump.

Test 5: Push-ups (30 seconds) test

Figure 5. Push-ups (30 seconds) test

From a starting position of a "push up", the maximum number of contractions and stretching of the arms (elbows to the side) are performed for 30 seconds. When performing the push-ups, the body is stretched, the legs are together, the head is an extension of the spine. When the arms are folded, the chest touches a previously placed cube with a height of 10 cm between the arms. We count the number of push-ups where the cube is touched.

Test 6: Sit-ups (30 seconds) test

Figure 6. Sit-ups (30 seconds) test

From a starting position of "sitting with legs forward, arms crossed in front of the chest", a the athlete lies down and then reaches again the starting position. The legs are held by a partner. The body rises to a vertical position. The exercise is performed a maximum number of times in 30 seconds.

Test 7: Squat jumps (30 seconds) test

Figure 7. Squat jumps (30 seconds) test

From a standing position the athlete squats down and performs a vertical jump with the hands up un the air. During the landing, the athlete squats again and the cycle is repeated. The maximum number of repetitions for 30 seconds is taken into account.

RESULTS

Table 3. *Variational analysis of Test "Stand and reach"*

Age	n	X min	Xmax	R	`C	S	V	As	Ex	JB	SIG.
4-6 y/o	66	-7	12	19	2,75	3,56	129,52	-0,082	1,133	3,606	0,165
7-9 y/o	82	-9	12	21	2,46	4,48	182,28	-0,351	0,599	2,909	0,234
10-11 y/o	37	-10,5	17	27,5	4,73	4,97	105,08	-0,389	2,005 *	7,135	0,028
12-14 y/o	23	-16	18	34	1,20	7,69	643,26	-0,274	0,931	1,119	0,572

Table 4. *Descriptive values for "Stand and reach" for taekwondo*

	Margins			
	4-6 y/o	**7-9 y/o**	**10-11 y/o**	**12-14 y/o**
very high	above 10	above 11	above 15	above 17
high	7 to 10	8 to 11	11 to 15	10 to 17
above average	6 to 6	6 to 7	8 to 10	6 to 9
average	2 to 5	1 to 5	3 to 7	-2 to 5
below average	0 to 1	-1 to 0	1 to 2	-5 to -3
low	-4 to -1	-7 to -2	-5 to 0	-14 to -6
very low	under -4	under -7	under -5	under -14

Table 5. *Variational analysis of Test "Split"*

Age	n	X min	Xmax	R	`C	S	V	As	Ex	JB	SIG.
4-6 y/o	66	2	30	28	14,32	5,36	37,40	0,226	0,723	1,998	0,368
7-9 y/o	82	0	28	28	12,79	7,42	58,04	-0,132	-1,008	3,709	0,156
10-11 y/o	38	0	35	35	14,50	9,06	62,51	0,029	-0,787	0,987	0,611
12-14 y/o	20	0	48	48	23,70	12,17	51,37	0,249	-0,055	0,209	0,901

Table 6*. Descriptive values for "Split" for taekwondo*

	Margins			
	4-6 y/o	**7-9 y/o**	**10-11 y/o**	**12-14 y/o**
very high	under 4	under -2	under -4	under -1
high	4 to 9	-2 to 5	-4 to 5	-1 to 12
above average	10 to 12	6 to 9	6 to 10	13 to 18
average	13 to 17	10 to 17	11 to 19	19 to 30
below average	18 to 20	18 to 20	20 to 24	31 to 36
low	21 to 25	21 to 28	25 to 33	37 to 48
very low	above 25	above 28	above 33	above 48

Table 7. *Variational analysis of "Three cone Test"*

Age	n	X min	Xmax	R	`C	S	V	As	Ex	JB	SIG.
4-6 y/o	41	10,9	19,8	8,9	14,18	1,95	13,78	1,125 *	1,42	12,08	0,002
7-9 y/o	46	10	16,2	6,2	12,21087	1,57	12,90	0,994*	0,53	8,108	0,017
10-11 y/o	16	9,7	12,2	2,5	10,56	0,84	7,98	0,844	-0,624	2,160	0,340
12-14 y/o	17	8	11,8	3,8	10,11	0,90	8,90	-0,371	1,127	1,289	0,525

Table 8. *Descriptive values for "3 cone test" for taekwondo*

	Margins			
	4-6 y/o	**7-9 y/o**	**10-11 y/o**	**12-14 y/o**
very high	under 10,3	under 9,1	under 8,9	under 8,3
high	10,3 to 12,2	9,1 to 10,6	8,9 to 9,7	8,3 to 9,2
above average	12,3 to 13,2	10,7 to 11,4	9,8 to 10,1	9,3 to 9,7
average	13,3 to 15,2	11,5 to 13,0	10,2 to 11	9,8 to 10,6
below average	15,3 to 16,1	13,1 to 13,8	11,1 to 11,4	10,7 to 11
low	16,2 to 18,1	13,9 to 15,4	11,5 to 12,2	11,1 to 11,9
very low	above 18,1	above 15,5	above 12,2	above 11,9

Table 9. *Variational analysis of Test "Vertical jump"*

Age	**n**	**X min**	**Xmax**	**R**	**`C**	**S**	**V**	**As**	**Ex**	**JB**	**SIG.**
4-6 y/o	40	3	28	25	15,23	4,82	31,64	0,008	0,759	0,961	0,618
7-9 y/o	61	12	34	22	21,21	5,05	23,79	0,373	-0,246	1,565	0,457
10-11 y/o	34	8	48	40	27,41	7,81	28,50	0,186	0,954	1,485	0,476
12-14 y/o	22	22	56	34	33,59	8,88	26,43	1,116*	0,946	5,384	0,068

Table 10*. Descriptive values for "Vertical jump" for taekwondo*

Evaluation	**Margins**			
	4-6 y/o	**7-9 y/o**	**10-11 y/o**	**12-14 y/o**
very high	above 25	above 31	above 43	above 51
high	21 to 25	27 to 31	36 to 43	43 to 51
above average	19 to 20	25 to 26	32 to 35	39 to 42
average	14 to 18	20 to 24	25 to 31	30 to 38
below average	11 to 13	17 to 19	21 to 24	26 to 29
low	6 to 10	11 to 16	12 to 20	16 to 25
very low	under 6	under 11	under 12	under 16

Table 11*. Variational analysis of Test "Push-ups (30 seconds)"*

Age	**n**	**X min**	**Xmax**	**R**	**`C**	**S**	**V**	**As**	**Ex**	**JB**	**SIG.**
4-6 y/o	36	3	28	25	12,08	6,12	50,65	0,359	-0,256	0,870	0,647
7-9 y/o	58	2	39	37	19,43	8,57	44,10	0,146	-0,43	0,654	0,721
10-11 y/o	36	4	35	31	18,33	7,41	40,40	0,185	-0,546	0,653	0,722
12-14 y/o	24	3	35	32	20,15	7,90	39,22	-0,069	-0,093	0,027	0,986

Table 12. *Descriptive values for "Push-ups (30 seconds)" for taekwondo*

Evaluation	Margins			
	4-6 y/o	**7-9 y/o**	**10-11 y/o**	**12-14 y/o**
very high	above 24	above 37	above 33	above 36
high	19 to 24	29 to 37	27 to 33	29 to 36
above average	16 to 18	25 to 28	23 to 26	25 to 28
average	10 to 15	16 to 24	16 to 22	17 to 24
below average	7 to 9	12 to 15	12 to 15	13 to 16
low	0 to 6	2 to 11	4 to 11	4 to 12
very low	under 0	under 2	under 4	under 4

Table 13. *Variational analysis of Test "Sit-ups (30 seconds)"*

Age	n	X min	Xmax	R	`C	S	V	As	Ex	JB	SIG.
4-6 y/o	32	5	25	20	14,47	5,02	34,71	0,022	-0,67	0,602	0,740
7-9 y/o	59	8	34	26	19,53	4,43	22,71	0,32	1,535 *	6,801	0,033
10-11 y/o	38	11	30	19	20,55	4,18	20,35	0,221	0,108	0,328	0,849
12-14 y/o	24	17	33	16	25,08	4,61	18,40	-0,18	-0,965	1,060	0,589

Table 14*. Descriptive values for "Sit-ups (30 seconds)" for taekwondo*

Evaluation	Margins			
	4-6 y/o	**7-9 y/o**	**10-11 y/o**	**12-14 y/o**
very high	above 25	above 28	above 29	above 34
high	20 to 25	25 to 28	26 to 29	31 to 34
above average	18 to 19	23 to 24	24 to 25	28 to 30
average	13 to 17	18 to 22	19 to 23	24 to 27
below average	10 to 12	16 to 17	17 to 18	21 to 23
low	4 to 9	11 to 15	12 to 16	16 to 20
very low	under 4	under 11	under 12	under 16

Table 15*. Variational analysis of Test "Squat jump (30 seconds)"*

Age	n	X min	Xmax	R	`C	S	V	As	Ex	JB	SIG.
4-6 y/o	31	8	29	21	19,48	6,20	31,83	-0,06	-1,065	1,484	0,476
7-9 y/o	57	15	38	23	25,80	4,91	19,03	0,113	-0,268	0,292	0,864
10-11 y/o	37	11	32	21	22,54	5,22	23,14	-0,516	-0,387	1,871	0,392
12-14 y/o	24	12	33	21	25,29	5,47	21,64	-1,072*	0,666	5,038	0,081

Table 16. *Descriptive values for "Squat jump (30 seconds)" for taekwondo*

Evaluation	Margins			
	4-6 y/o	**7-9 y/o**	**10-11 y/o**	**12-14 y/o**
very high	above 32	above 36	above 33	above 36
high	27 to 33	32 to 36	29 to 33	32 to 36
above average	24 to 26	29 to 31	26 to 28	29 to 31
average	17 to 23	24 to 28	21 to 25	24 to 28
below average	14 to 16	22 to 23	18 to 20	21 to 23
low	7 to 13	16 to 21	12 to 17	14 to 20
very low	under 7	under 16	under 12	under 14

Table 17. *Descriptive values for 50 grade assessment 4-6 y/o male taekwondo athletes*

Stand and reach	Split	3 cone test	Vertical jump	Push-ups (30 sec.)	Sit-ups (30 sec.)	Squat jumps (30 sec.)	Points	Evaluation
12	1	9,3	27	27	27	35	**50**	HIGH
11	1	9,5	27	27	27	34	**49**	
11	2	9,7	26	26	26	34	**48**	
11	3	9,9	26	26	26	33	**47**	
10	3	10,1	25	25	25	33	**46**	
10	4	10,3	25	24	25	32	**45**	ABOVE AVERAGE
10	4	10,5	24	24	24	31	**44**	
9	5	10,7	24	23	24	31	**43**	
9	5	10,9	23	22	23	30	**42**	
8	6	11,1	23	22	23	29	**41**	
8	6	11,2	22	21	22	29	**40**	
8	7	11,4	22	21	22	28	**39**	
7	7	11,6	21	20	21	28	**38**	
7	8	11,8	21	19	20	27	**37**	
7	8	12	21	19	20	26	**36**	
6	9	12,2	20	18	19	26	**35**	AVERAGE
6	9	12,4	20	18	19	25	**34**	
6	10	12,6	19	17	18	24	**33**	
5	11	12,8	19	16	18	24	**32**	
5	11	13	18	16	17	23	**31**	
5	12	13,2	18	15	17	23	**30**	
4	12	13,4	17	15	16	22	**29**	
4	13	13,6	17	14	16	21	**28**	
3	13	13,8	16	13	15	21	**27**	
3	14	14	16	13	15	20	**26**	
3	14	14,2	15	12	14	19	**25**	
2	15	14,4	15	11	14	19	**24**	
2	15	14,6	14	11	13	18	**23**	
2	16	14,8	14	10	13	18	**22**	
1	16	15	13	10	12	17	**21**	
1	17	15,2	13	9	12	16	**20**	
1	18	15,4	12	8	11	16	**19**	
0	18	15,5	12	8	11	15	**18**	
0	19	15,7	11	7	10	15	**17**	
0	19	15,9	11	7	10	14	**16**	
-1	20	16,1	10	6	9	13	**15**	
-1	20	16,3	10	5	9	13	**14**	BELOW

-2	21	16,5	9	5	8	12	**13**	
-2	21	16,7	9	4	8	11	**12**	
-2	22	16,9	8	4	7	11	**11**	
-3	22	17,1	8	3	7	10	**10**	
-3	23	17,3	8	2	6	10	**9**	
-3	23	17,5	7	2	6	9	**8**	
-4	24	17,7	7	1	5	8	**7**	
-4	24	17,9	6	0	5	8	**6**	
-4	25	18,1	6	0	4	7	**5**	
-5	26	18,3	5	-1	4	6	**4**	**LOW**
-5	26	18,5	5	-1	3	6	**3**	
-5	27	18,7	4	-2	3	5	**2**	
-6	27	18,9	4	-3	2	5	**1**	
-6	28	19,1	3	-3	2	4	**0**	

Table 18. *Descriptive values for 50 grade assessment 7-9 y/o male taekwondo athletes*

Stand and reach	Split	3 cone test	Vertical jump	Push-ups (30 sec.)	Sit-ups (30 sec.)	Squat jumps (30 sec.)	Points	Evaluation
14	-6	7,8	34	41	31	38	**50**	**HIGH**
13	-5	7,9	33	40	30	38	**49**	
13	-4	8,1	33	39	30	37	**48**	
12	-4	8,3	32	38	29	37	**47**	
12	-3	8,5	32	37	29	36	**46**	
11	-2	8,6	31	37	28	36	**45**	**ABOVE AVERAGE**
11	-1	8,8	31	36	28	35	**44**	
11	-1	9	30	35	28	35	**43**	
10	0	9,1	30	34	27	34	**42**	
10	1	9,3	29	33	27	34	**41**	
9	2	9,5	29	32	26	33	**40**	
9	2	9,7	28	31	26	33	**39**	
8	3	9,8	28	31	25	32	**38**	
8	4	10	27	30	25	32	**37**	
7	5	10,2	27	29	24	31	**36**	
7	5	10,3	26	28	24	31	**35**	**AVERAGE**
6	6	10,5	26	27	24	30	**34**	
6	7	10,7	25	26	23	30	**33**	
6	8	10,9	25	25	23	29	**32**	
5	8	11	24	25	22	29	**31**	
5	9	11,2	24	24	22	28	**30**	
4	10	11,4	23	23	21	28	**29**	
4	11	11,5	23	22	21	27	**28**	
3	11	11,7	22	21	20	27	**27**	
3	12	11,9	22	20	20	26	**26**	
2	13	12,1	21	19	20	26	**25**	
2	14	12,2	21	19	19	25	**24**	
2	14	12,4	20	18	19	25	**23**	
1	15	12,6	20	17	18	24	**22**	
1	16	12,7	19	16	18	24	**21**	
0	17	12,9	19	15	17	23	**20**	
0	17	13,1	18	14	17	23	**19**	
-1	18	13,3	18	13	16	22	**18**	
-1	19	13,4	17	13	16	22	**17**	
-2	19	13,6	17	12	16	21	**16**	

-2	20	13,8	16	11	15	21	**15**	
-2	21	13,9	16	10	15	20	**14**	**BELOW AVERAGE**
-3	22	14,1	15	9	14	20	**13**	
-3	22	14,3	15	8	14	19	**12**	
-4	23	14,5	14	7	13	19	**11**	
-4	24	14,6	14	7	13	18	**10**	
-5	25	14,8	13	6	12	18	**9**	
-5	25	15	13	5	12	17	**8**	
-6	26	15,1	12	4	12	17	**7**	
-6	27	15,3	12	3	11	16	**6**	
-7	28	15,5	11	2	11	16	**5**	
-7	28	15,7	11	1	10	15	**4**	**LOW**
-7	29	15,8	10	1	10	15	**3**	
-8	30	16	10	0	9	15	**2**	
-8	31	16,2	9	-1	9	14	**1**	
-9	31	16,3	9	-2	8	14	**0**	

Table 19. *Descriptive values for 50 grade assessment 10-11 y/o male taekwondo athletes*

Stand and reach	**Split**	**3 cone test**	**Vertical jump**	**Push-ups (30 sec.)**	**Sit-ups (30 sec.)**	**Squat jumps (30 sec.)**	**Points**	**Evaluation**
17	-8	8,5	47	37	31	36	**50**	**HIGH**
17	-7	8,5	46	36	31	35	**49**	
16	-6	8,6	45	35	30	35	**48**	
16	-5	8,7	45	35	30	34	**47**	
15	-5	8,8	44	34	29	33	**46**	
15	-4	8,9	43	33	29	33	**45**	**ABOVE AVERAGE**
14	-3	9	42	32	29	32	**44**	
14	-2	9	41	32	28	32	**43**	
13	-1	9,1	41	31	28	31	**42**	
13	0	9,2	40	30	27	31	**41**	
12	1	9,3	39	29	27	30	**40**	
12	2	9,4	38	29	26	30	**39**	
11	3	9,5	38	28	26	29	**38**	
11	4	9,6	37	27	26	29	**37**	
10	5	9,6	36	26	25	28	**36**	
10	5	9,7	35	26	25	28	**35**	**AVERAGE**
9	6	9,8	34	25	24	27	**34**	
9	7	9,9	34	24	24	27	**33**	
8	8	10	33	24	23	26	**32**	
8	9	10,1	32	23	23	26	**31**	
7	10	10,1	31	22	23	25	**30**	
7	11	10,2	31	21	22	25	**29**	
6	12	10,3	30	21	22	24	**28**	
6	13	10,4	29	20	21	24	**27**	
5	14	10,5	28	19	21	23	**26**	
5	15	10,6	27	18	21	23	**25**	
4	15	10,6	27	18	20	22	**24**	
4	16	10,7	26	17	20	21	**23**	
3	17	10,8	25	16	19	21	**22**	
3	18	10,9	24	15	19	20	**21**	
2	19	11	24	15	18	20	**20**	
2	20	11,1	23	14	18	19	**19**	
1	21	11,2	22	13	18	19	**18**	

1	22	11,2	21	12	17	18	**17**	
0	23	11,3	20	12	17	18	**16**	
0	24	11,4	20	11	16	17	**15**	
-1	24	11,5	19	10	16	17	**14**	**BELOW AVERAGE**
-1	25	11,6	18	9	16	16	**13**	
-2	26	11,7	17	9	15	16	**12**	
-2	27	11,7	16	8	15	15	**11**	
-3	28	11,8	16	7	14	15	**10**	
-3	29	11,9	15	6	14	14	**9**	
-4	30	12	14	6	13	14	**8**	
-4	31	12,1	13	5	13	13	**7**	
-5	32	12,2	13	4	13	13	**6**	
-5	33	12,2	12	4	12	12	**5**	
-6	34	12,3	11	3	12	12	**4**	**LOW**
-6	34	12,4	10	2	11	11	**3**	
-7	35	12,5	9	1	11	11	**2**	
-7	36	12,6	9	1	11	10	**1**	
-8	37	12,7	8	0	10	10	**0**	

Table 20. *Descriptive values for 50 grade assessment 12-14 y/o male taekwondo athletes*

Stand and reach	Split	3 cone test	Vertical jump	Push-ups (30 sec.)	Sit-ups (30 sec.)	Squat jumps (30 sec.)	Points	Evaluation
20	-7	7,9	56	40	37	39	**50**	**HIGH**
20	-6	8	55	39	36	38	**49**	
19	-4	8	54	38	36	38	**48**	
18	-3	8,1	53	38	35	37	**47**	
17	-2	8,2	52	37	35	37	**46**	
17	-1	8,3	51	36	34	36	**45**	**ABOVE AVERAGE**
16	1	8,4	50	35	34	36	**44**	
15	2	8,5	50	34	33	35	**43**	
14	3	8,6	49	34	33	35	**42**	
14	4	8,7	48	33	32	34	**41**	
13	5	8,8	47	32	32	34	**40**	
12	7	8,9	46	31	32	33	**39**	
11	8	8,9	45	30	31	32	**38**	
10	9	9	44	30	31	32	**37**	
10	10	9,1	43	29	30	31	**36**	
9	12	9,2	42	28	30	31	**35**	**AVERAGE**
8	13	9,3	42	27	29	30	**34**	
7	14	9,4	41	26	29	30	**33**	
7	15	9,5	40	26	28	29	**32**	
6	16	9,6	39	25	28	29	**31**	
5	18	9,7	38	24	27	28	**30**	
4	19	9,8	37	23	27	27	**29**	
4	20	9,8	36	23	26	27	**28**	
3	21	9,9	35	22	26	26	**27**	
2	22	10	34	21	26	26	**26**	
1	24	10,1	34	20	25	25	**25**	
0	25	10,2	33	19	25	25	**24**	
0	26	10,3	32	19	24	24	**23**	
-1	27	10,4	31	18	24	24	**22**	
-2	29	10,5	30	17	23	23	**21**	
-3	30	10,6	29	16	23	23	**20**	

-3	31	10,7	28	15	22	22	**19**	
-4	32	10,7	27	15	22	21	**18**	
-5	33	10,8	26	14	21	21	**17**	
-6	35	10,9	26	13	21	20	**16**	
-6	36	11	25	12	20	20	**15**	
-7	37	11,1	24	11	20	19	**14**	**BELOW AVERAGE**
-8	38	11,2	23	11	20	19	**13**	
-9	40	11,3	22	10	19	18	**12**	
-10	41	11,4	21	9	19	18	**11**	
-10	42	11,5	20	8	18	17	**10**	
-11	43	11,6	19	8	18	17	**9**	
-12	44	11,6	18	7	17	16	**8**	
-13	46	11,7	18	6	17	15	**7**	
-13	47	11,8	17	5	16	15	**6**	
-14	48	11,9	16	4	16	14	**5**	
-15	49	12	15	4	15	14	**4**	**LOW**
-16	50	12,1	14	3	15	13	**3**	
-16	52	12,2	13	2	14	13	**2**	
-17	53	12,3	12	1	14	12	**1**	
-18	54	12,4	11	0	14	12	**0**	

DISCUSSION

High kicks are taekwondo's trademark and in order to be able to execute them a taekwondo athlete must possess a high level of flexibility in the lower limbs of his or her body. The first two tests – "Stand and reach" and "Side Split", give information specifically about that quality. Apart from that the "Stand and reach" also tests the lower back flexibility. One of the most used kicks in taekwondo – the "Neryo chagi" or the "Axe" kick relies on that type of flexibility. And even though the Excess value is over critical in the 10 – 11 years old (Ex=2,005), we believe the results are conclusive in terms of higher values for higher age groups.

It has never been determined exactly what level of flexibility must a taekwondo athlete possess, but the general perception is that an athlete should be able to perform a "side split". Another issue derives from the fact that most of the kicks are performed at head level and it has not been determined what is the excess amount of flexibility that a taekwondo athlete should possess in order to better execute kicks and to prevent injuries from high amplitude motions. Taekwondo competitors are divided into categories on a weight basis but in many cases an athletes possess a significant height advantage, making it harder for the shorter athlete to reach the head of the opponent. According to the results described in **Table 3,** the age group 12 – 14 years old should possess a lesser level of flexibility than the previous one, which might be due to the specifics of the flexibility development in connection with the age.

Speed and agility are essential in taekwondo, and this modified "3 cone test" should present a better notion of the development of these qualities in a taekwondo athlete of the specific age. The dynamics of a taekwondo fight require quick decision making and change of direction depending on the actions and counteractions of the opponent. The asymmetry index For the "3 cone test" of two groups (4-6 and 7 – 9 years old) are above the critical (As_{4-6}=1,125 and As_{7-9}=0,994), which requires further investigation. Dynamic power is essential for kicking and that is why the development of this quality should be traced from an early age. The "Horizontal jump" test is easy to perform and does not require a difficult execution technique to be mastered. The results we achieved are conclusive in terms of distribution of values and will be a valuable tool in the assessment of the physical development of the athlete.

The arms are used mainly for defense and very little for offense in taekwondo, hence the anaerobic endurance in the lower limbs is of the highest importance in taekwondo. However, we deemed necessary to perform the "Push-ups (30 sec)" test since it would give an insight into the overall physical development of a taekwondo athlete compared to a regular person of the same age. It was interesting to compare the acquired data with such from the older age groups since we believed that the length of the upper limbs

would be a factor in the result for the age groups "Juniors" and "Seniors".

The core muscle endurance is important in taekwondo for many reasons, as well as for the fact that the athletes actually receive maximum impact hits to the body. Even though during a taekwondo match the athletes wear protective equipment for the body ("hogu"), one must still possess strong core muscles. The data of the "Sit ups (30 sec)" test for the second age group (Children I 7-9 years) has a greater than the critical value of Ex7-9=1,535 **(Table 11).** As mentioned before, the anaerobic endurance in the lower limbs is the most important physical quality in taekwondo. The results of our research for the "Squat jump test (30 sec)" were interesting since only one of the indexes was above the critical value (As_{12-14}=-1,072). The interesting find was the maximum and the minimum values for the normative data. As seen on **Table 14**, the maximum value for the first two age groups (4-6 and 7-9 y/o) follows a logical increase (+4), but the next age groups – 10 11 y/o drop down again to 33 repetitions and the Cadet age group (12 – 14 y/o) again increases to 36 repetitions. The minimum values for "very low" follow a similar pattern with age groups "Children II" = under 12 repetitions and "Cadets" = under 14 repetitions, both under the required minimum for the age group "Children I" = 16 repetitions. We believe that this could be related to the height of the athletes tested since the younger age groups possess lower height than the older groups and the overall distance that the body travels while squatting down and jumping in the air is greater for the older groups.

Visualizing the data is most of the time crucial in understanding it, especially by the general public.

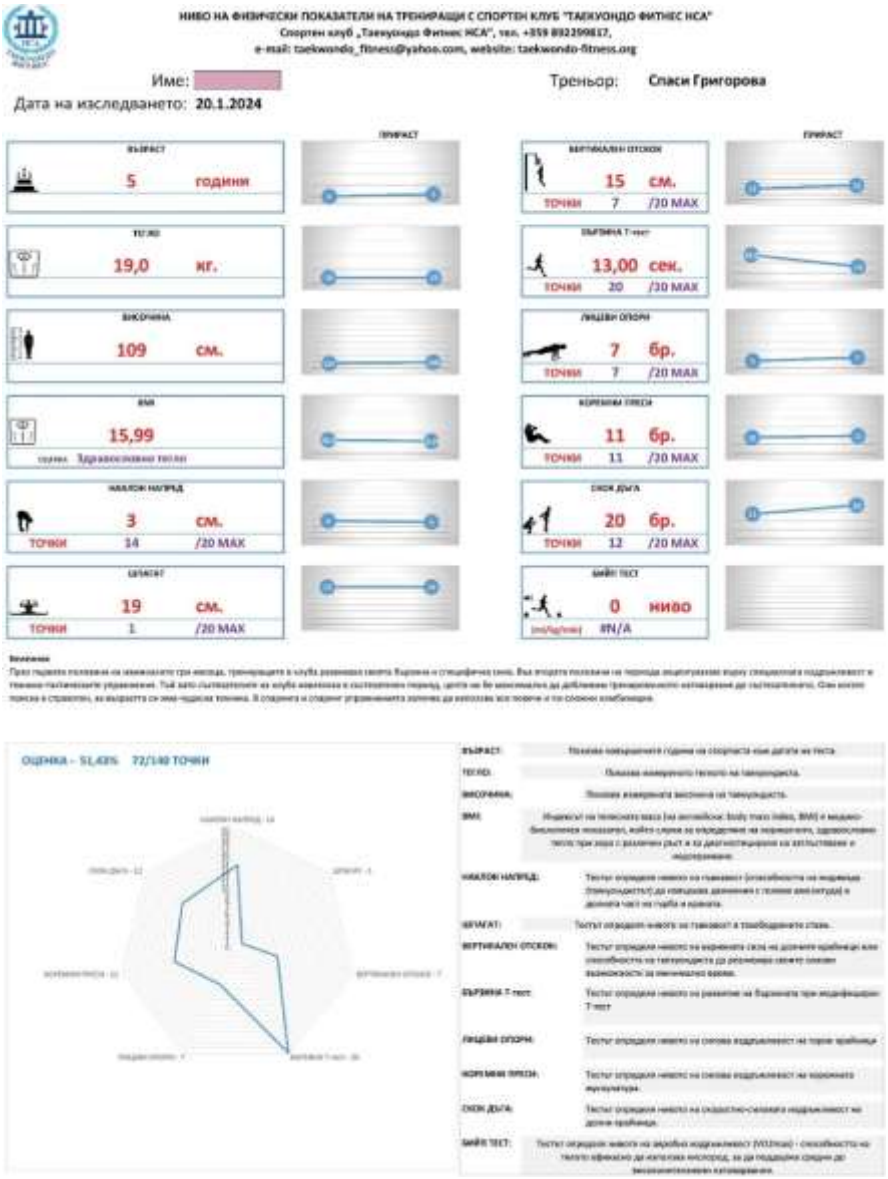

Figure 8. Visualization of the progress and evaluation of the results of the athletes.

In our opinion, the proposed visualization makes it easier to understand the results. Based on a 20 scale ranking system, it shows the achieved results, compares them to the previously achieved ones and gives a score, based on the normative data developed. Furthermore, it gives an overall assessment of the physical abilities of the athlete based on a 20 point scale (with 140 points from the seven tests as a maximum score and transferred to a percentage). We believe that using our radar chart will be quite easy to comprehend the results immediately, and will give a quick feedback to both coaches and athletes on their weak and strong sides.

CONCLUSIONS

The Olympic sport of taekwondo is putting more and more stress on the physical abilities of the athletes. That is why we think that the creation of a normative system for evaluation of the physical development of taekwondo athletes is long overdue. Such a system will provide crucial feedback about the efficiency of the training methods, current physical condition and will be of motivational use for athletes. In addition, since taekwondo is extremely popular amongst young children, such feedback will give comprehensible feedback to parents. The results of our study, presented in the tables, are a starting point for building a database for taekwondo. They can also serve as a basis for overall evaluation of taekwondo athletes. It has to be taken into consideration that with some of the tests the younger athletes can have better results than the older ones. For example on Test 7 “Squat jump”, younger athletes have less movement due to their smaller size and can have better results which is visible in the normative scale. However, we recommend further research in order for the system to be flawless. The tests included in the test battery were selected also due to their relatively easy application in the field. It is important for the coaches that the tests are quick and easy to be carried out. The proposed tests can measure the development of physical qualities in young taekwondo male athletes. This will further benefit the training process by providing feedback to coaches so they can optimize the training programs.

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