NORMATIVE BASE FOR ASSESSMENT AND OPTIMIZATION MODELS OF ANAEROBIC CAPACITY IN TAEKWON-DO ATHLETES

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Abstract. *The present study aimed to create a system for evaluating anaerobic capacity in ITF athletes of both sexes. Methodology: The study was conducted in the period 2015-2023 and a total of 142 athletes of both sexes participated, distributed as follows (men aged 20.14±3.2 years; weight 75.59±13.26 kg; height 179, 93±7 cm and women aged 22.18±5.2 years; weight 60.68±8.69 kg; height 165.53±5.07 cm). Results: Age and gender specifics are considered when evaluating the competitors. The development of a normative basis for evaluation in training activities allows for modern scientific management of sports training, which is a prerequisite for the purposeful and effective development of athletes. From the scientific point of view, we should consider the fact that it is expedient to select the candidates whose aggregate control score is over 25 points. This division is conditional, and sports professionals should bear in mind that with higher criteria the minimum aggregate score may rise to 78.82% for athletes who score 40 or more points. Conclusion: Regular control during the training process and comparison of the obtained results with the prepared normative base allows for effective management and targeted planning of the training loads, as well as the use of various means and methods for reporting the effect of the applied training influences.*

Keywords: *Wingate test; maximum anaerobic power; male; female.*

Introduction

Performing fast and powerful movements for a long time in Taekwon-Do necessitates good development of both anaerobic and aerobic capacity (Hammad et al., 2019). The good development of motor qualities and psychological abilities of athletes will also increase physiological efficiency, which is an indicator of the ability of athletes to compete and progress in sports. Improved anaerobic capacity can generate energy at a high rate, which delays the onset of muscle fatigue and allows maintenance of high-intensity work (Tayech et al., 2020). Taekwon-do training involves a continuous jumping regimen, striking with the lower limbs at a great height for a period, which requires aerobic fitness (Ooi & Anowar, 2018).

According to the requirements of the International Taekwon-do Federation ITF, good performance in competitions requires athletes to apply complex coordinated movements that include maximum speed, high power, and absolute precision. This competitive model of Taekwon-do is characterized by phases of simultaneously repetitive physical activity of low and high intensity (Sant´Ana et al., 2014).

Factors that determine the nature of Taekwon-do during meetings include a high level of technical preparation of the athlete, sporting experience, good knowledge and adherence to the rules of competition, and level of physical fitness, all of which influence movement execution and therefore competition success. Taekwon-do competitions heavily emphasize the execution of kicks with the lower limbs, which, depending on the style, are performed at speeds of 6 to

16 m/s. In addition, the distance between opponents (≈2 m) required striking movements to be performed in a time window of 0.12 to 0.31 s. The dynamics of competitive meetings and the physiological demands of Taekwon-do (especially in the lower weight categories) often produce peak heart rates and highly elevated blood lactate levels of 11-14 mmol/l. A significant anaerobic energy expenditure is observed, although always maintained by the aerobic energy pathway. Anaerobic muscle metabolism is critical during the impact phases. At the same time, the aerobic system is dominant during non-strike moments (active recovery) and plays an important role in the body's ability to regenerate energy (Sant´Ana et al., 2014). The metabolic demands of Taekwon-do when performing high-intensity, short-duration kicks indicate that successful Taekwon-do training must include repetitive training loads performed at maximal force, maximal velocity, and high frequency. Thus, the athlete must be able to repeatedly deliver powerful attacks over time without rapid and significant fatigue arising.

According to the authors, an effective training protocol for improved anaerobic capacity with increased tolerance to exercise-induced metabolic acidosis will include exercise that improves anaerobic glycolysis but includes incomplete recovery periods. The work-to-recovery ratio should be 1:3, incorporating 10-30 s of maximal effort (which will increase lactate) and blood and muscle clearance rates, inducing physiological adaptations that allow high performance despite homeostatic imbalance.

According to Tayech et al., (2020), Taekwon-do bouts typically consist of three 2-minute rounds separated by 1-minute rest intervals, and during the rounds competitors perform high-intensity techniques (e.g. scoring or defensive techniques) followed by periods of low intensity (e.g. staggered action or referee stoppages). During competitive matches, athletes perform short periods of attacks (1–6 s) followed by longer periods of rest (ratios between attack and hold ranging between 1:2–1:7). Racing elicits high heart rate responses (>90% peak heart rate, HR peak) and moderate to high lactate concentration (7.0–12.2 mmol. l-1). Taekwon-do competitors require high anaerobic and aerobic power to effectively manage metabolic demands during bouts. Aerobic and anaerobic power are crucial determinants of success in this sport. Male Taekwon-do medalists were found to have higher anaerobic power scores on the Wingate test than their non-medal counterparts. In addition, there was a tendency for male and junior medalists to show higher aerobic power on the shuttle multistage test than their non-medalist counterparts.

During the training process, the load should be aimed at a combination of general and special physical training, so that coordination complex and difficult movements are more easily mastered and executed during competition (Liu & Jia, 2023). According to some authors, motor ability is seen as a prerequisite for improving performance and sports success (Nabilpour et al., 2023). A strong relationship has been established between psychological factors and the anaerobic and aerobic capabilities of the body. A difference was observed in the fatigue index, which indicates the rate of decrease in power output within 30 seconds (Onuma et al., 2023).

Studies by several authors (Rohsler et al., 2020; Wilson et al., 2009; Rocha et al., 2016; Kadlec et al., 2022; Monteiro de Moura et al., 2017) address the issue of body position during the performance of the Wingate test. According to them, there shouldn't be much difference in results between standing and sitting. It has been established that if the subject stands up from the seat during a sit-down test, this change should not affect his/her physiological changes. However, moving from one position to another during the test is not recommended due to the

potential of injury. It should be recognized that there may be reasons for specifying one position over another (eg injuries, weight, limb length, degree of core stability). Due to the physiological and biomechanical differences between wheel pedaling and lower extremity stroke performance, the need for specificity in the testing protocol was considered.

Another factor that also has an impact is related to the time interval of the test. Researchers (Souissi et al., 2007; Lericollais et al., 2011; Chtourou et al., 2011) have drawn attention to the fact that oral temperature is higher at 18:00 than at 06:00. Thus, the higher value of Ppeak and Pmean in the evening than in the morning may be related to changes in body temperature. It is assumed that a higher body temperature can enhance metabolic reactions, increase the extensibility of connective tissue, reduce muscle viscosity, and increase the speed of action potentials. During warm-up and cool-down, maximum anaerobic power was found to drop by 5% for every 18C drop in muscle temperature. However, the mean range of variation in oral temperature observed during the day was low (0.88C) and appears insufficient to fully explain the changes observed in the muscle contraction property (i.e., 8% differences in peak and average power). Poorer performance observed in the morning compared to the afternoon may be due to impairment or reduced participation in aerobic energy production. It is recommended that the tests be conducted at the time of the expected competition (if known in advance and possible).

Interest in the Wingate test is based on its simplicity as a testing protocol, peak power, little sophisticated equipment, and short duration (Hamdi et al., 2014).

The present study aimed to create a system for evaluating anaerobic capacity in ITF athletes of both sexes.

Methodology: The study was conducted in the period 2015-2023 and a total of 142 athletes of both sexes participated, distributed as follows (men aged 20.14±3.2 years; weight 75.59±13.26 kg; height 179, 93±7 cm and women aged 22.18±5.2 years; weight 60.68±8.69 kg; height 165.53±5.07 cm).

The subjects were athletes from the Bulgarian ITF Taekwon-do national team in different age groups and weight categories of both sexes. Thanks to this, athletes with a high sports level from various cities in Bulgaria are covered. Competitors have passed the phase of specialized pre-selection for admission to participate with the national team. The tests are conducted in laboratory conditions, during the preparatory camp meetings, before the European Championship and the World Championship for the respective calendar year.

The test is carried out after a preliminary 10-minute warm-up, the athlete begins to pedal at maximum frequency without resistance. Within 3 seconds, the resistance is raised to a certain degree and the athlete continues to pedal at maximum frequency for 30 s. The load is adjusted to the body mass of the person examined. The standard formula is that 1 kilogram of body mass corresponds to 0.075 kg of resistance exerted by the pedals. An electric counter registers the number of revolutions in 5s intervals. The test is performed on a mechanical cycle ergometer Monark 894 E (Sweden).

The indicators are calculated:

- Peak power – the realized highest power in the first 5 s of the load reflects the capacity of the system for the immediate release of energy (the high-energy phosphate compounds ATP and CF).
- The relative peak power refers to 1 kg of body mass.

- Fatigue index – the indicator provides information on the percentage reduction of sustained fatigue.
- Anaerobic capacity – gives information about the total amount of work done in 30 s.

Changes in metrics will be examined: peak power (w; w/kg), average power (w; w/kg), performance decline (%), and maximum rpm of the athletes. To achieve a more complete analysis of the studied indicators, data on the height and weight of the studied persons are additionally presented.

Mathematical and statistical methods: descriptive statistics, Sigma, and percentile method for developing norms. Data were statistically analyzed with SPSS.v.25.

Results

Despite the specific requirements for adjusting the load when conducting the Wingate test about the body weight of the subjects, we consider it proper that the results of the competitors, and especially the normative tables for evaluating their achievements, should be differentiated by age and gender (table 1).

Table 1. *Average values of indicators*

Indicator	Mean ± SD Male (n=74)	Mean ± SD Female (n=68)
Age	20.14±3.21	22.18±5.22
Height	179.93±7.01	165.53±5.07
Weight	75.59±13.26	60.68±8.69
Peak power w	912.66±209.80	588.82±104.39
Peak power w/kg	12.00±1.31	9.73±1.21
Average power w	649.23±117.82	425.34±64.10
Average power w/kg	8.58±0.60	7.04±0.75
Fatigue Index	53.34±8.76	53.15±9.15
Maximum RPM	145.68±9.50	127.77±9.51
Anaerobic capacity	18525.72±3304.4	12448.57±1865.5

Two ways were used to present the assessments of sports achievements - a point assessment (T-rating scale) from 0 to 50 and a verbal assessment from poor to excellent. The best sports achievements receive 50 points and a verbal evaluation excellent (practically 99.73% of cases have results from 10 to 40 points).

T-scores are applied as a unified evaluation measure and the possibility to compare scores in different tests, to average scores from different measuring scales of a given quality, also for different groups of subjects.

For each test separately (table 2-6), the corresponding points are calculated for the athlete from the normative tables, which are divided into two age groups (up to 20 years and 21-30 years) and gender (men and women).

Table 2. *Normative table of the "Peak power" indicator*

Peak power	Peak power

Points	Men (up to 20 years)	Women (up to 20 years)	Men (21-30 years)	Women (21-30 years)
50	1261.00	744.00	1393.00	840.00
49	1216.28	719.20	1364.40	815.10
48	1171.56	694.40	1335.80	790.20
47	1126.84	669.60	1307.20	765.30
46	1082.12	644.80	1278.60	740.40
45	1037.40	619.90	1250.00	715.50
44	1031.31	616.71	1240.50	712.50
43	1025.22	613.52	1231.00	709.50
42	1019.13	610.33	1221.50	706.50
41	1013.04	607.14	1212.00	703.50
40	1006.95	603.95	1202.50	700.50
39	1000.86	600.76	1193.00	697.50
38	994.77	597.57	1183.50	694.50
37	988.68	594.38	1174.00	691.50
36	982.59	591.19	1164.50	688.50
35	976.50	588.24	1155.00	685.50
34	956.35	581.94	1132.10	671.50
33	936.20	575.64	1109.20	657.50
32	916.05	569.34	1086.30	643.50
31	895.90	563.04	1063.40	629.50
30	875.75	556.74	1040.50	615.50
29	855.60	550.44	1017.60	601.50
28	835.45	544.14	994.70	587.50
27	815.30	537.84	971.80	573.50
26	795.15	531.54	948.90	559.50
25	774.80	525.24	926.00	545.50
24	755.16	516.54	880.40	532.50
23	735.52	507.84	834.80	519.50
22	715.88	499.14	789.20	506.50
21	696.24	490.44	743.60	493.50
20	676.60	481.74	698.00	480.50
19	659.53	471.94	691.50	474.50
18	642.46	462.14	685.00	468.50
17	625.39	452.34	678.50	462.50
16	608.32	442.54	672.00	456.50
15	591.25	432.74	665.50	450.50
14	574.18	422.94	659.00	444.50
13	557.11	413.14	652.50	438.50
12	540.04	403.34	646.00	432.50
11	522.97	393.54	639.50	426.50
10	505.90	383.74	633.00	420.50
9	488.83	373.94	626.50	414.50
8	471.76	364.14	620.00	408.50
7	454.69	354.34	613.50	402.50
6	437.62	344.54	607.00	396.50
5	420.55	334.74	600.50	390.50
4	403.48	324.94	594.00	384.50
3	386.41	315.14	587.50	378.50
2	369.34	305.34	581.00	372.50
1	352.27	295.54	574.50	366.50
0	335.20	285.74	568.00	360.50
$\bar{x} \pm S$	866.13±187.7	556.65±82.22	998.58±227.64	615.76±114.05
Excellent	1261.00-1037.41	744.00-619.91	1393.00-1250.01	840.00-715.51
Good	1037.40-976.51	619.90-588.25	1250.00-1155.01	715.50-685.51
Regular	976.50-676.61	588.24-481.75	1155.00-698.01	685.50-480.51
Poor	676.60-420.55	481.74-334.74	698.00-600.50	480.50-390.50

Very poor	<420.55	<334.74	<600.50	<390.50

The evaluation of the peak power of the competitors can be done in several ways:

1. With the help of the verbal evaluation - qualitative evaluations from poor to excellent - for the convenience of the coaches and from a practical point of view, a 5-level normative scale is indicated.

2. Using a quantitative assessment (T-scale) from 0 to 50 points.

3. Comparative analysis - between the two age groups of the same sex or between the two sexes in the same age group.

For the "peak power" indicator, the difference in the middle of the rating scale (25 points) for men is 151.2 w, while for women it is 20.26 w. At the top of the rating scale (50 points), the difference for men decreases to 132 w, while for women it increases to 96 w.

Table 3. *Normative table of the "peak power w/kg" indicator*

	Peak power w/kg		Peak power w/kg	
Points	Men (up to 20 years)	Women (up to 20 years)	Men (21-30 years)	Women (21-30 years)
50	14.10	12.30	14.80	12.80
49	13.90	12.00	14.65	12.50
48	13.70	11.70	14.50	12.20
47	13.50	11.40	14.35	11.90
46	13.30	11.10	14.20	11.60
45	13.10	10.80	14.05	11.30
44	13.02	10.72	13.97	11.24
43	12.94	10.64	13.89	11.18
42	12.86	10.56	13.81	11.12
41	12.78	10.48	13.73	11.06
40	12.70	10.40	13.65	11.00
39	12.62	10.32	13.57	10.94
38	12.54	10.24	13.49	10.88
37	12.46	10.16	13.41	10.82
36	12.38	10.08	13.33	10.76
35	12.30	10.00	13.25	10.70
34	12.20	9.92	13.08	10.56
33	12.10	9.84	12.91	10.42
32	12.00	9.76	12.74	10.28
31	11.90	9.68	12.57	10.14
30	11.80	9.60	12.40	10.00
29	11.70	9.52	12.23	9.86
28	11.60	9.44	12.06	9.72
27	11.50	9.36	11.89	9.58
26	11.40	9.28	11.72	9.44
25	11.30	9.20	11.55	9.30
24	11.15	9.08	11.39	9.07
23	11.00	8.96	11.23	8.84
22	10.85	8.84	11.07	8.61
21	10.70	8.72	10.91	8.38
20	10.55	8.60	10.75	8.15
19	10.41	8.44	10.67	8.13
18	10.27	8.28	10.59	8.11
17	10.13	8.12	10.51	8.09
16	9.99	7.96	10.43	8.07

15	9.85	7.80	10.35	8.05
14	9.71	7.64	10.27	8.03
13	9.57	7.48	10.19	8.01
12	9.43	7.32	10.11	7.99
11	9.29	7.16	10.03	7.97
10	9.15	7.00	9.95	7.95
9	9.01	6.84	9.87	7.93
8	8.87	6.68	9.79	7.91
7	8.73	6.52	9.71	7.89
6	8.59	6.36	9.63	7.87
5	8.45	6.20	9.55	7.85
4	8.31	6.04	9.47	7.83
3	8.17	5.88	9.39	7.81
2	8.03	5.72	9.31	7.79
1	7.89	5.56	9.23	7.77
0	7.75	5.40	9.15	7.75
$\bar{x} \pm S$	11.83±1.17	9.60±1.30	12.33±1.50	9.83±1.12
Excellent	14.10-13.11	12.30-10.81	14.80-14.06	12.80-11.31
Good	13.10-12.31	10.80-10.01	14.05-13.26	11.30-10.71
Regular	12.30-10.56	10.00-8.61	13.25-10.76	10.70-8.16
Poor	10.55-8.45	8.60-6.20	10.75-9.55	8.15-7.85
Very poor	<8.45	<6.20	<9.55	<7.85

The evaluation of the "peak power/kg" indicator is identical and the sports specialist can choose to assign a verbal or point evaluation. The comparison at 25 points, which covers the regular zone, shows a difference of 0.25 w/kg in men and 0.10 w/kg in women. The area of the maximum rating ‘’Excellent’ shows an increase in the difference for men and extends to 0.70 w/kg and for women - up to 0.50 w/kg.

Table 4. *Normative table of the indicator "Average power"*

	Average power		Average power	
Points	Men (up to 20 years)	Women (up to 20 years)	Men (21-30 years)	Women (21-30 years)
50	829.00	507.00	854.00	551.00
49	808.15	499.20	846.30	543.46
48	787.30	491.40	838.60	535.92
47	766.45	483.60	830.90	528.38
46	745.60	475.80	823.20	520.84
45	724.75	468.00	822.50	513.30
44	720.80	463.40	818.27	503.88
43	716.85	458.80	814.04	494.46
42	712.90	454.20	809.81	485.04
41	708.95	449.60	805.58	475.62
40	705.00	445.00	801.35	466.20
39	701.05	440.40	797.12	456.78
38	697.10	435.80	792.89	447.36
37	693.15	431.20	788.66	437.94
36	689.20	426.60	784.43	428.52
35	685.25	422.00	780.20	419.10
34	675.43	417.70	768.14	417.32
33	665.61	413.40	756.08	415.54
32	655.79	409.10	744.02	413.76
31	645.97	404.80	731.96	411.98
30	636.15	400.50	719.90	410.20

29	626.33	396.20	707.84	408.42
28	616.51	391.90	695.78	406.64
27	606.69	387.60	683.72	404.86
26	596.87	383.30	671.66	403.08
25	587.05	379.00	659.60	401.30
24	563.68	375.70	641.70	394.58
23	540.31	372.40	623.80	387.86
22	516.94	369.10	605.90	381.14
21	493.57	365.80	588.00	374.42
20	470.20	362.50	570.01	367.70
19	461.12	356.70	562.88	361.69
18	452.04	350.90	555.75	355.68
17	442.96	345.10	548.62	349.67
16	433.88	339.30	541.49	343.66
15	424.80	333.50	534.36	337.65
14	415.72	327.70	527.23	331.64
13	406.64	321.90	520.10	325.63
12	397.56	316.10	512.97	319.62
11	388.48	310.30	505.84	313.61
10	379.40	304.50	498.71	307.60
9	370.32	298.70	491.58	301.59
8	361.24	292.90	484.45	295.58
7	352.16	287.10	477.32	289.57
6	343.08	281.30	470.19	283.56
5	334.00	275.50	463.06	277.55
4	324.92	269.70	455.93	271.54
3	315.84	263.90	448.80	265.53
2	306.76	258.10	441.67	259.52
1	297.68	252.30	434.54	253.51
0	288.60	246.50	427.41	247.50
$\bar{x} \pm S$	623.96±114.80	406.80±51.73	695.88±110.74	440.87±69.80
Excellent	829.00-724.76	507.00-468.01	854.00-822.51	551.00-513.31
Good	724.75-685.26	468.00-422.01	822.50-780.21	513.30-419.11
Regular	685.25-470.21	422.00-362.51	780.20-570.02	419.10-367.71
Poor	470.20-334.00	362.50-275.50	570.01-463.06	367.70-277.55
Very poor	<334.00	<275.50	<463.06	<277.55

The average power developed by the competitors again shows extra-large differences between the representatives of the two sexes. In the first age group (up to 20 years), the difference between men and women is 208.05 w for average grades and increases to 322 w for excellent grades. In the next age group, we observe a difference of 258.3 w in average grades, which reaches 303 w in excellent grades.

Table 5. *Normative table of the indicator "Average power w/kg"*

	Average power w/kg		Average power w/kg	
Points	Men (up to 20 years)	Women (up to 20 years)	Men (21-30 years)	Women (21-30 years)
50	9.60	8.10	9.80	8.30
49	9.52	8.04	9.70	8.22
48	9.44	7.98	9.60	8.14
47	9.36	7.92	9.50	8.06
46	9.28	7.86	9.40	7.98
45	9.20	7.80	9.30	7.90
44	9.16	7.77	9.28	7.88

43	9.12	7.74	9.26	7.86
42	9.08	7.71	9.24	7.84
41	9.04	7.68	9.22	7.82
40	9.00	7.65	9.20	7.80
39	8.96	7.62	9.18	7.78
38	8.92	7.59	9.16	7.76
37	8.88	7.56	9.14	7.74
36	8.84	7.53	9.12	7.72
35	8.80	7.50	9.10	7.70
34	8.75	7.44	9.04	7.58
33	8.71	7.38	8.98	7.46
32	8.67	7.32	8.92	7.34
31	8.62	7.26	8.86	7.22
30	8.58	7.20	8.80	7.10
29	8.54	7.14	8.74	6.98
28	8.49	7.08	8.68	6.86
27	8.45	7.02	8.62	6.74
26	8.41	6.96	8.56	6.62
25	8.37	6.90	8.50	6.50
24	8.32	6.77	8.40	6.46
23	8.28	6.64	8.30	6.42
22	8.24	6.51	8.20	6.38
21	8.20	6.38	8.10	6.34
20	8.16	6.25	8.00	6.30
19	8.07	6.16	7.96	6.28
18	7.98	6.07	7.92	6.26
17	7.89	5.98	7.88	6.24
16	7.80	5.89	7.84	6.22
15	7.71	5.80	7.80	6.20
14	7.62	5.71	7.76	6.18
13	7.53	5.62	7.72	6.16
12	7.44	5.53	7.68	6.14
11	7.35	5.44	7.64	6.12
10	7.26	5.35	7.60	6.10
9	7.17	5.26	7.56	6.08
8	7.08	5.17	7.52	6.06
7	6.99	5.08	7.48	6.04
6	6.90	4.99	7.44	6.02
5	6.81	4.90	7.40	6.00
4	6.72	4.81	7.36	5.98
3	6.63	4.72	7.32	5.96
2	6.54	4.63	7.28	5.94
1	6.45	4.54	7.24	5.92
0	6.36	4.45	7.20	5.90
$\bar{x} \pm S$	8.53±0.59	7.01±0.81	8.67±0.61	7.06±0.69
Excellent	9.60-9.21	8.10-7.81	9.80-9.31	8.30-7.91
Good	9.20-8.81	7.80-7.51	9.30-9.11	7.90-7.71
Regular	8.80-8.17	7.50-6.26	9.10-8.01	7.70-6.31
Poor	8.16-6.81	6.25-4.90	8.00-7.40	6.30-6.00
Very poor	<6.81	<4.90	<7.40	<6.00

If we look at the values of the same indicator relative to the body weight of the competitors, we observe differences of 1.47 w/kg in the average grades at the age of 20 years and increases to 1.50 w/kg in the excellent grades. The second age group shows differences of 2.00 w/kg in average grades and decreases to 1 w/kg in excellent grades.

Table 6. *Normative table of the indicator "Anaerobic capacity (J)"*

Points	Anaerobic capacity Men (up to 20 years)	Anaerobic capacity Women (up to 20 years)	Anaerobic capacity Men (21-30 years)	Anaerobic capacity Women (21-30 years)
50	23705,20	15019,40	24188,10	15432,80
49	23180,20	14810,20	23842,30	15351,10
48	22655,20	14601,00	23496,50	15269,40
47	22130,20	14391,80	23150,70	15187,70
46	21605,20	14182,60	22804,90	15106,00
45	21080,20	13973,40	22459,10	15024,30
44	20985,70	12809,10	22288,50	14950,70
43	20891,20	13644,80	22117,90	14877,10
42	20796,70	13480,50	21947,30	14803,50
41	20702,20	13316,20	21776,70	14729,90
40	20607,70	13151,90	21606,10	14656,30
39	20513,20	12987,60	21435,50	14582,70
38	20418,70	12823,30	21264,90	14509,10
37	20324,20	12659,00	21094,30	14435,50
36	20229,70	12494,70	20923,70	14361,90
35	20135,50	12330,40	20753,10	14288,30
34	19771,30	12199,20	20561,20	14030,30
33	19407,10	12068,00	20369,30	13772,30
32	19042,90	11936,80	20177,40	13514,30
31	18678,70	11805,60	19985,50	13256,30
30	18314,50	11674,40	19793,60	12998,30
29	17950,30	11543,20	19601,70	12740,30
28	17586,10	11412,00	19409,80	12482,30
27	17221,90	11280,80	19217,90	12224,30
26	16857,70	11149,60	19026,00	11966,30
25	16493,50	11018,40	18834,10	11708,30
24	15988,40	10949,42	18557,98	11528,70
23	15483,30	10880,44	18281,86	11349,10
22	14978,20	10811,46	18005,74	11169,50
21	14473,10	10742,48	17729,62	10989,90
20	13968,00	10673,50	17453,49	10810,30
19	13699,16	10507,30	17120,09	10638,80
18	13430,32	10341,10	16786,69	10467,30
17	13161,48	10174,90	16453,29	10295,80
16	12892,64	10008,70	16119,89	10124,30
15	12623,80	9842,50	15786,49	9952,80
14	12354,96	9676,30	15453,09	9781,30
13	12086,12	9510,10	15119,69	9609,80
12	11817,28	9343,90	14786,29	9438,30
11	11548,44	9177,70	14452,89	9266,80
10	11279,60	9011,50	14119,49	9095,30
9	11010,76	8845,30	13786,09	8923,80
8	10741,92	8679,10	13452,69	8752,30
7	10473,08	8512,90	13119,29	8580,80
6	10204,24	8346,70	12785,89	8409,30
5	9935,40	8180,50	12452,49	8237,80
4	9666,56	8014,30	12119,09	8066,30
3	9397,72	7848,10	11785,69	7894,80
2	9128,88	7681,90	11452,29	7723,30
1	8860,04	7515,70	11118,89	7551,80
0	8591,20	7349,50	10785,49	7380,30
$\bar{x} \pm S$	18010,81±3427,27	11883,96±1530,44	19476,35±2889,97	12921,61±2005,23

Excellent	23705,20-21080,21	15019,40-13973,41	24188,10-22459,11	15432,80-15024,31
Good	21080,20-20135,51	13973,40-12330,41	22459,10-20753,11	15024,30-14288,31
Regular	20135,50-13968,01	12330,40-10673,51	20753,10-17453,50	14288,30-10810,30
Poor	13968,00-9935,40	10673,50-8180,50	17453,49-12452,49	10810,30-8237,80
Very poor	<9935,40	<8180,50	<12452,49	<8237,80

If we look at the anaerobic capacity values of the athletes, we observe extra-large differences between the excellence of both sexes in the two age groups considered. In men, the difference in mean score was 1465.54 J, while in women the difference in average score was 1037.65 J. Men demonstrated better-developed anaerobic capabilities in both age groups studied.

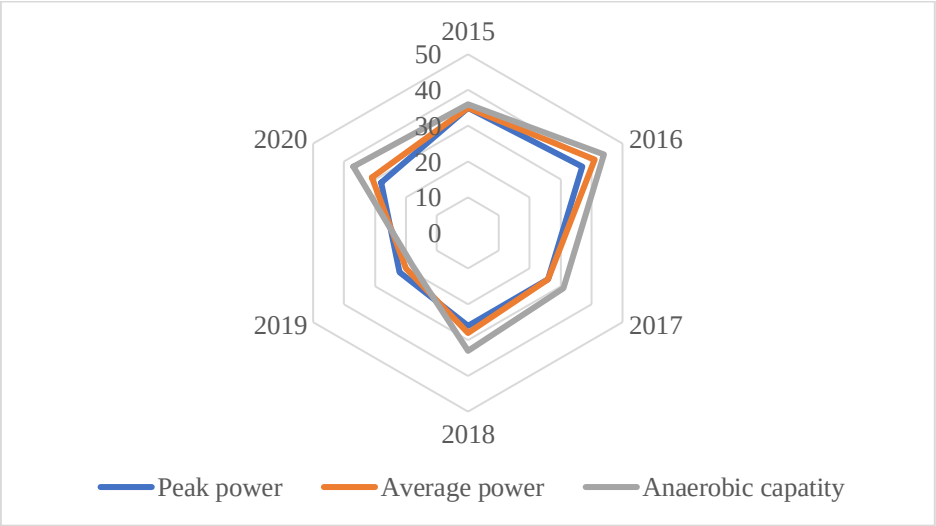

Figure 1. Optimization model of R. Sh. (man)

The optimization model of the multiple European and world champions (figure 1) covers two age periods - up to 20 years and 21-30 years. We noticed that in 2015-2016 when he still meets the standards for the first age group, the grades are close to the maximum. Subsequently, the period shows a sharp decline in sports results in 2017 and 2019.

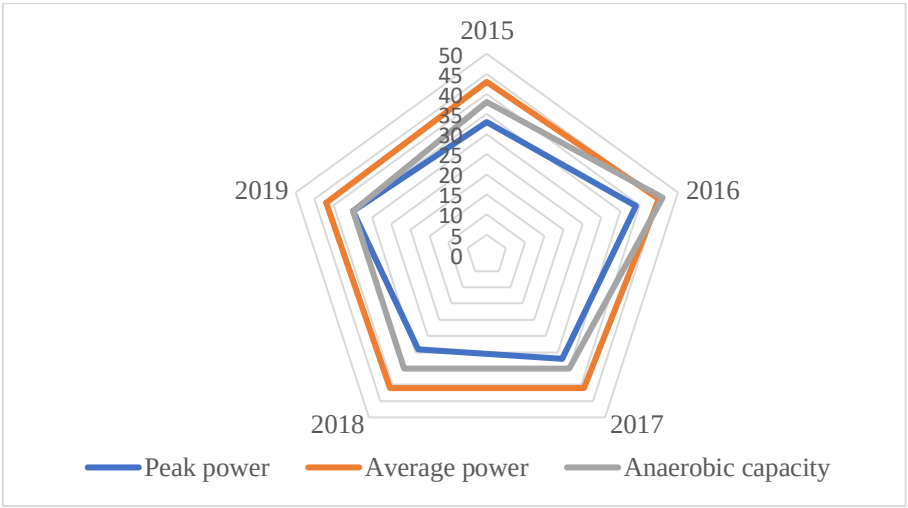

Figure 2. Optimization model of A. S. (woman)

The optimization model of A.S. (figure 2), who has been a multiple European and world champion, covers only the second age period of assessment 21-30 years. The competitor shows a very good development of the studied indicators throughout the considered period.

Discussion and Conclusions

Many authors are supporters of the Wingate test for evaluating the anaerobic capabilities of Taekwon-do competitors (Alp & Gorur, 2020; Boutios et al., 2022; Rocha et al., 2016; Sant´Ana et al., 2014; Tayech et al., 2020) and even liken it as the "Gold Standard". According to others, specialized tests related to the specific features of combat sports should be applied. According to Tayech et al., (2020), a sport-specific intermittent kick test (TAIKT) may be a more specific and easy measure of anaerobic power in Taekwon-do athletes. The test is valid and characterized by a good ability to differentiate between elite and sub-elite Taekwon-do athletes. The test is designed to assess anaerobic power, while determining absolute and relative peak power (Ppeak) and average power (Pmean), as well as fatigue index (FI). Measuring the anaerobic strength of Taekwon-do fighters will allow the execution of more Taekwon-do-specific movements, such as kicking, basic technique during attack and counterattack, and the execution of several punches in sequence. Taekwon-do competitors must have high anaerobic capacity to effectively manage energy demands during competition. The Wingate 30-second anaerobic test (WanT) is a valid and reliable tool for the assessment of anaerobic power and functional performance in elite athletes. Sant'Ana et al. (2014) propose a new sport-specific anaerobic assessment method using the Bandal chagui kick performance. The greatest number of techniques are performed against a punching bag. no anaerobic capacity evaluation criterion (laboratory assessment of power and anaerobic capacity) was used to validate this Taekwon-do-specific test, which made it impossible to understand the calculated level of this test to predict the values obtained in the reference test. TSAT should estimate the ideal monitoring model (anaerobic capacity) that should theoretically be related to WanT. Due to a decrease in motor acuity when performing Bandal chagui with fatigue, techniques begin to be performed in areas further away from the center of the shield/sensor with lower impact values than the actual force applied. The results obtained show that TSAT has a level of agreement with WanT, especially in the variables PP, RPP, MAP, RMAP, and FI, therefore the protocol gives great specificity in the assessment of the anaerobic capacity of Taekwon-do athletes. The problem of sensor sensitivity, which can cause permanent drift, should be further investigated by further experiments with an improved power estimation tool capable of maintaining a minimum level of measurement accuracy that ensures that any large part of the surface of the impact shield must include a sufficient number of sensors to ensure the recording of every possible type and degree of impact on it Rocha et al., (2016).

A Taekwon-do-specific aerobic-anaerobic agility test (TAAA) is proposed by Tayech et al., (2020). The test is structured according to the specific motor activity typically performed during competition and training, but also in a way that allows assessment of the three key motor components of interest (i.e. agility, aerobic power, and anaerobic fitness). The TAAA test

involves six 20-second intervals of shuttle sprints over a 4-meter distance and execution of lower limb circular kicks (i.e. bandal chagi in Taekwon-do terminology - the most used leg kicks in competition and training) alternating legs at the end of this distance.

The TST test is a simple and practical tool for coaches and requires no invasive equipment. A total of seven specialized sidekicks (with the left front leg (i.e. "Yop-Chagi"), a right leg kick (in Taekwon-do terminology referred to as "Bandal-Chagi") and followed by a second back kick with another leg (in Taekwon-do terminology, called "Dwit-Chagi")). The test is a measure of planned four-way agility and body control, which assesses the ability to quickly change directions as well as maintain balance without losing speed (Aloui et al., 2022).

Autoregulatory progressive resistance exercise (APRE) is more favorable for improving lower extremity explosive power, while velocity-based resistance training (VBRT) is more favorable for improving lower extremity anaerobic power. Both methods showed similar effects in improving the rate of power decay and fatigue index (Huang et al., 2024).

The specialized tests discussed are useful for practice and the training process, but in our opinion, they cannot replace the Wingate test. They can be a supplement to it and give the coaches a more complete picture of the successful realization of the goals set by them in the training and competition process.

Laboratory and field control are extremely important for success in the training and competition process. However, there are other factors that directly or indirectly affect the sports results and performance of athletes. The researchers Akgul et al., 2023; Coelho-e-Silva et al., 2020; Rhyu & Cho, 2014; Sun et al., 2022; Taati et al., 2022) believe that the lack of control over the diet, the intake of certain foods or supplements, as well as the athletes' diet for a targeted reduction in body weight, can negatively affect aerobic capacity, Wingate test results and performance during competition. Submaximal VO2, which allows efficient use of energy in training and competition, has been implicated as the reason for the differences in performance levels of athletes with an equivalent level of VO2 max. Individual differences in the use of oxygen consumption have been found. Targeted weight loss should be carefully controlled because of the established impaired performance of athletes associated with deliberate changes in weight before competition.

According to Nikolaidis & Knechtle (2021), the prediction of individual results and their comparison with previous ones is particularly important in periods when this test should not be administered given the fatigue it causes.

Consistent with the present study are the results of Khayyat et al., (2020). The presented examination methods and test results can be used to evaluate the performance of Taekwon-Do competitors and select talented athletes. This will also help coaches to properly plan training programs and evaluate the results in the different phases. To properly manage the energy demands of competition, the ability of high anaerobic power, especially for the lower extremities, to produce high peak power is an important prerequisite. A higher peak power output of 14.7 W/kg in Czech national Taekwon-do team players was found compared to Turkish athletes who had higher anaerobic peak power and average power than was evident in some of the national teams in other countries. The values were higher than those of Portuguese, Czech, and Taiwanese elite athletes (Khayyat et al., 2020). Compared with the data of the present study, we can conclude that the results of the Czech national team on the peak power

output approach the maximum results obtained by the Bulgarian national athletes in the age group 21-30 years.

The conclusions of the study by Boraczyński et al., (2017) confirm the present study and the conclusion that young men and women have lower values and show differences during the individual stages of development, which is a consequence of longer training and competition experience and greater training loads in favor of men and the women.

Normative tables for evaluating the various indicators in Taekwon-do will support the training and competition process. Using the five-point rating scale Franchini (2019) or the 50-point system proposed in the present study (five-point verbal rating) will be an advantage for sports professionals. These values can be used as a starting point to guide the anaerobic training of judo athletes and can be relevant for setting goals regarding anaerobic capacity peaking for a particular competition or during different phases of the recovery process. It is also important to note that absolute PP and MP did not differ between successive weight classes, which may be related to the anthropometric similarity found in competitors of successive weight classes, particularly in terms of skinfold thickness and circumferences. (Franchini, 2019).

Individual differences in training programs need to be taken into account, and the data obtained will vary for different athletes (Lin & Ding, 2023). The difference in motor ability plays a key role in the competition performance of athletes (Liu & He, 2022).

Regular control during the training process and comparison of the obtained results with the prepared normative base allows for effective management and targeted planning of the training loads, as well as the use of various means and methods for reporting the effect of the applied training influences.

An advantage of the developed normative basis for assessment is the possibility of monitoring the indicators over a longer period, specialized for the relevant gender.

The dividing lines between verbal assessments define the boundary below and above which caution is needed, especially in the preparation of national competitors. Through the verbal evaluation, a qualitative assessment and comparison between the results of the same competitor on the different measured indicators can be applied. The use of the T-rating scale and verbal evaluations will optimize the evaluation and improve the control of Taekwon-do players based on the average typical level of each indicator.

Age and gender specifics are considered when evaluating the competitors. The development of a normative basis for evaluation in training activities allows for modern scientific management of sports training, which is a prerequisite for the purposeful and effective development of athletes. From the scientific point of view, we should consider the fact that it is expedient to select the candidates whose aggregate control score is over 25 points. This division is conditional, and sports professionals should bear in mind that with higher criteria the minimum aggregate score may rise to 78.82% for athletes who score 40 or more points.

When evaluating competitors, diet or dieting, time of day for the test, injuries, overexertion, and other factors that may reduce the competitor's score, and rating must be considered.

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