INTERDEPENDECE OF BODY OXYGEN REGIMES CHARACTERISTICS AND TECHNICAL AND TACTICAL ACTIONS IN TAEKWONDO

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Relevance. Constant striving to make taekwondo more spectacular leads to a reduction of rounds, the rest interval in between, the introduction of regulations in the competition rules, encouraging the fighter to an active conduct of the bout. Under these conditions, technical and tactical actions can be seriously limited due to the energy capacities of the body. And although the work in taekwondo is considered of variable intensity, while the attacks themselves are mainly performed in the anaerobic alactate regime (10-12 s), the duration of rounds (from 1.5 to 3 min) and the total duration of the bout make us assume anaerobic glycolysis and oxidative phosphorylation mainly involved in the energy supply. At least earlier studies have shown [4, 5] that the level of maximal oxygen consumption in taekwondokas is not much different from that of the typical representatives of aerobic sports. Hence, the question arises about the relationship between the characteristics of the oxygen regime in the body and the technical and tactical actions in taekwondo, which was the subject of this study.

Materials and methods. 20 taekwondokas - members of the youth national team of Surgut were involved in the research. Sparrings were carried out in three two-minute rounds with a 1 min rest interval between the rounds. Before the bout, all participants performed standard warm-up exercises typical in this sport. The parameters of the body oxygen regime were registered at rest, in between the rounds and during the 1st and 4th minutes of recovery after the bout using the hardware and software complex "Fitmate PRO". Heart rate (HR) was measured using the "Polar" monitor without intervals during the whole bout. Psychophysiological characteristics of athletes were estimated by means of the hardware and software complex "Activatiometer". Technical and tactical actions (TTA) were evaluated based on the results of the video recording. Effective actions were fixated by means of the electronic monitoring system.

Results and discussion. The average parameters of the body oxygen regime during taekwondo sparrings are presented in Table 1. As seen from them, higher parameters of external respiration are observed before the first round rather than at rest [6], which is due to the previously performed warm-up. Functional organization of the external respiratory system is conditioned by the presence of relationships between its parameters. According to them, after warming up before the bout it is only lung ventilation (RMV) that is critical for body's oxygen supply. The relationship of oxygen consumption (O_2C) with RMV is r=0.917, p<0.01, with breathing capacity (BC) – r=0.572, p<0.01 irrespective of the breathing pattern. With that, oxygen utilization coefficient (O_2UC) is correlated only with exhaled oxygen (r=-0,996, p<0.01), which testifies to the special value of diffusive capacity of the lungs in delivering qualitative ventilation.

Table 1. *Parameters of the body oxygen regime and technical and tactical actions in taekwondo, n=20*

Indicators	After warming up	First round	First rest	Second round	Second rest	Third round	1 min rest	3 min rest
	M±σ	M±σ	M±σ	M±σ	M±σ	M±σ	M±σ	M±σ
Respiratory rate, n/min	22± 7.5	37± 9*	26± 7*	40± 8*	31± 8*	43± 7*	34± 7*	27± 7*
Breathing capacity, l	0.58± 0.31	1.93± 0.66*	1.46± 0.75*	1.94± 0.62*	1.40± 0.57*	1.73± 0.60*	1.37± 0.58*	0.99± 0.52*
Respiratory minute volume, l/min	11.88± 4.84*	68.34± 20.56*	36.24± 14.67*	76.47± 24.71*	42.62± 16.47*	73.89± 22.84*	46.01± 18.51*	26.39± 12.01*
Oxygen consumption, ml/min	374.7 ± 135.4	2509.8± 690.8*	1069.3± 363.3*	2723.1± 827.8*	1141.6± 480.1*	2623.5± 742.1*	1212.1 ± 443.6*	692.2 ± 264.7*
Concentration of O_2 in the exhaled air, %	17.08± 0.52	16.19± 0.86*	17.16± 0.61	16.33± 0.53*	17.52± 0.76*	16.32± 0.52*	17.56± 0.54*	17.57± 0.54*
O_2 utilization coefficient, vol. %	38.90± 5.51	44.98± 8.59*	37.34± 6.52	44.02± 5.31*	33.50± 7.61*	44.04± 5.51*	33.13± 5.71*	33.47± 5.58*
Hildebrand coefficient, c.u.	5.40± 2.12	4.92± 1.11	5.39± 1.39	4.73± 0.88	4.96± 1.16	4.42± 0.66*	4.51± 0.81	4.72± 1.29
Heart rate, bpm	106± 14	174± 27*	134± 23*	183± 22*	147± 17*	187± 24*	147± 19*	121± 14*
Number of technical and tactical actions		19.55± 6.63		19.35± 6.13		18.40± 6.36		
Number of points received		1.78± 1.37		1.68± 1.78		1.40± 0.68		
PC		0.094± 0.078		0.088± 0.086		0.081± 0.046		
TTA1/TTA3	1.13±0.033							
PC1/PC3	1.28±1.07							

* – changes are significant compared with initial indices, p<0.05.

After the first round, O_2C increased by 720%, RMV - by 629%, BC – by 412% and respiratory rate (RR) – by 185%. O_2C lagging behind from the RMV increment can be explained by the significant enhancement of ventilation effectiveness and the increase of O_2UC by 17%. This increase can be caused both by the improving coupling of ventilation and blood flow [7, 9], and the increase in the volume of the functioning respiratory tissue, which contributes to acceleration of the oxygen mass-transfer within the respiratory divisions of the lungs [2, 3]. However, the main factors enabling O_2C after the first round are RMV and BC, as they are the only ones determining statistically significant relations with oxygen consumption ($r=0.824$, $p<0.01$ and $r=0.717$, $p<0.01$). Therefore, control of breathing during physical exercise is mainly realized by the partial pressure of arterial oxygen. Consolidation of the role of oxygen in breathing control during exercise is fully justified. It is oxygen deficit that limits oxidation processes in muscles when metabolism is increasing [8], thus forcing to maintain a particular level of the intracellular oxygen tension [1].

Negative relation of the effectiveness of breathing with concentration (FEO_2) of oxygen in the exhaled air ($r=-0.994$, $p<0.01$) and RR ($r=-0.495$, $p<0.05$) indicates that the increase of RR after the first round by 85% does not affect O_2C significantly. Moreover, the increase of RR leads to enlargement of the "respiratory dead space" and drop in ventilation effectiveness.

Further continuation of the bout does not change the main principles. Oxygen consumption reaches its maximum in the second round. Still, it is lung ventilation that is most essential (second round – $r=0.917$, $p<0.01$, third – r=0/919, p<0/01). Lung ventilation primarily depends on breathing depth (second round – $r=0.897$, $p<0.01$, third – $r=0.851$, $p<0.01$). The HR/RR ratio keeps decreasing (warm-up – 5.40±2.12, first round – 4.92±1.11, second – 4.73±0.88, third – 4.42±0.66, $p<0.05$).

However, new tendencies have been emerging, too: starting from the second round, the increasing percentage rate of respiration begins to correlate with O_2C (second round – $r=0.478$, $p<0.05$, – $r=0.506$, $p<0.05$). Probably, further deepening of breathing takes too much energy and the body starts using the auxiliary reserve in the form of RR. Yet, this enlarges the "respiratory dead space" and makes ventilation less effective, which is expressed in the emerging tendency towards reduction of O_2UC (first round – 44.98±8.59, second – 44.02±5.31, third – 41.04±5.51). In the second round the number and homogeneity of negative correlation relationships with O_2UC increases (with RR – $r=-0.631$, $p<0.01$, with RMV – $r=-0.465$, $p<0.05$, with FEO_2 – $r=-0.654$, $p<0.01$, with HR – $r=-0.557$, $p<0.01$).

Rest moments between the rounds are not enough to fully liquidate oxygen debt, and it accumulates progressively with each succeeding round (303, 320, 337%). Stable negation of the effectiveness of breathing is observed at the end of 1-minute rest (97, 87, 86%). Out of specific parameters of oxygen regime, it is only concentration of oxygen in the exhaled air that restores for the time of 1-minute rest. RR (128, 152, 170%) and RMV (326, 380, 410%) debts accumulate most significantly. BC debt reduces slightly (298, 277, 270%). All this aligns with the decrease in breathing depth in the third round (second round – 439%, third – 377%). Fatigue of respiratory muscles, that have a very low PC (3-6%), forces the body to shallow breathing at the end of the bout and contributes to the more complete restoration of BC for 1-minute recovery. 1-minute rest turns out to be not enough for HR recovery, too, and after the second rest it exceeds the upper limit of the recovery pulse adopted in sport (134±23, 147±17, 147±19 bpm).

Direct correlations were not observed between technical and tactical actions and their results and the parameters of oxygen regime in between the rounds, which once again stresses that sports result follows from the all-round manifestation of different aspects of athlete's fitness level. At the same time, direct correlations of oxygen regime are shown in relation to integrated aspects of training of athletes. Thus, with improvement of their skills, taekwondokas work with higher HR as early as in the first round ($r=0.435$, $p<0.05$), in the second round they have higher indices of BC ($r=0.508$, $p<0.05$), O_2C ($r=0.423$, $p<0.05$), HR ($r=0.520$, $p<0.05$), in the third round they have a higher pulse rate ($r=0.547$, $p<0.01$) and perform a larger number of TTA ($r=0.432$, $p<0.05$), during the recovery period they have higher indices of BC ($r=0.429$, $p<0.05$) and FEO_2 ($r=0.492$, $p<0.05$).

Total points for a bout are positively correlated with HR in the second round ($r=0.439$, $p<0.05$) and FEO_2 at the final stage of recovery ($r=0.468$, $p<0.05$). The level of special endurance as a relationship of TTA1/TTA3 is positively correlated with RR in the first ($r=0.456$, $p<0.05$), second ($r=0.548$, $p<0.01$) and final ($r=0.455$, $p<0.05$) rest periods, O_2C in the first round ($r=0.453$, $p<0.05$) and first recovery period ($r=0.455$, $p<0.05$), FEO_2 at rest ($r=0.552$, $p<0.01$), in the second round ($r=0.484$, $p<0.05$), in the third recovery period ($r=0.459$, $p<0.05$) and is negatively correlated with BC at the final stage of recovery ($r=-0.489$, $p<0.05$) and O_2UC at rest ($r=-0.528$, $p<0.01$) and in the second round ($r=-0.442$, $p<0.05$). The level of special endurance, defined as a relationship of PC1/PC3, is positively correlated only with FEO_2 in the first ($r=0.469$, $p<0.05$) and third ($r=0.465$, $p<0.05$) rounds and the first ($r=0.482$, $p<0.05$) and third ($r=0.507$, $p<0.05$) recovery periods and negatively – with O_2UC at rest ($r=0.422$, $p<0.05$).

Attention switch is the most important psychophysiological characteristic for a taekwondoka. That is why in our studies a significant relationship was detected between this indicator and a sports category ($r=0.560$, $p<0.01$) and the rating of sports achievements ($r=0.444$, $p<0.05$). Average response time of the left hand was 214±24 msec, of the right hand – 218±20 msec, which is described as a very agile nervous system. Time of motor reaction of the left hand is significantly correlated with the sports category ($r=-0.458$, $p<0.05$), the rating of sports achievements ($r=0.610$, $p<0.01$), PC in the second round ($r=0.508$, $p<0.05$) and O_2UC in the first round ($r=0.441$, $p<0.05$), first rest period ($r=-0.446$, $p<0.05$). Time of motor reaction of the right hand is correlated with multiple aspects but, generally, with vegetative indicators (for instance, with incomplete HR recovery after the third round - $r=0.501$, $p<0.05$, with O_2UC in the second recovery period – $r=-0.731$, $p<0.01$. Right brain activity is negatively correlated with O_2UC in the first ($r=-0.473$, $p<0.05$) and second ($r=-0.535$, $p<0.01$) recovery periods, and in the third round ($r=-0.467$, $p<0.05$).

The findings can be used to improve the quality of the training process and sports qualification in taekwondo.

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