Journal of Physical Education and Sport ® (JPES), 17(3), Art 182, pp. 1180 - 1185, 2017
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Hypoxic training as the basis for the special performance of karate sportsmen

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Published online: September 30, 2017
*(*Accepted for publication September 03, 2017
DOI:10.7752/jpes.2017.03182

Abstract:
Purpose: to develop a method of hypoxic training to increase the level of special physical fitness of karate sportsmen. The research tasks: to carry out the analysis of scientific and methodological literature on the determination of the laws of adaptation of the athlete's organism to the conditions of hypoxia; to determine the state of special physical preparedness of karate sportsmen of 16-17 years old; to develop the method of hypoxic training by the method of recurrent respiration into the closed space; To determine the most important factors in raising the level of special physical preparedness of karate sportsmen aged 16-17. **Results**: Ten sessions of hypoxic exposure during recurrent respiration in the closed space were performed. Interval hypoxic training was carried out on the basis of the body's reaction to the gradual decrease the volume of oxygen in the respiratory air. During the reverse breathing, the parameters of the cardiovascular system and the respiratory system were recorded in the closed space. The use of regression analysis made it possible to determine the main factors ensuring the duration of recurrent respiration. **Research materials indicate** studying testify the need for carrying out hypoxic training, since the increase in adaptability to hypoxia is the mechanism for the development of the special working capacity of karate sportsmen of 16-17 years old. **Conclusions**: the results of the study deepen information about the features of adaptive mechanisms to certain competitive activities. Inclusion of interval hypoxic training in the training process contributed to a more significant increase in the anaerobic performance of karate sportsmen of 16-17 years old.
Key words: adaptation, karate, recurrent respiration, hypoxia, normobaric hypoxia.

Introduction

The problem of training karate sportsmen of 16-17 years old is characterized by the fact that in the process of physical training it is necessary to solve specific sports problem [12, 19].

The motor qualities that contribute to the mastery of technical elements of karate ensure the ability of athletes to manifest specific motor functions: static and dynamic balance, accuracy of movements after rotation, maximum frequency of shock movements, accuracy of dynamic and spatial-temporal parameters of movements, restructuring of motor activity and coordination of movements, Elements [2, 10, 19].

It should be noted that all speed-power competitive activities take place under conditions of severe hypoxic action, and therefore the level of adaptability to hypoxia and individual sensitivity to lack of oxygen determine the effectiveness of competitive activity [4, 26].

The lack of objective data on the technology of hypoxic preparation of karate sportsmen has determined the direction of our studies.

Materials and methods.

Participants. In the studies, 18 karate sportsmen aged 16-17 years took part, having the level of training of the first sports category and a candidate for master of sports.

The main research methods: analysis and generalization of scientific and methodological literature, the method of recurrent respiration, frequency of heart beats (HB), coefficient of the use of oxygen (CO O_2), increase in pulmonary ventilation (respiration volume litre), breathing frequency (FB), respiratory volume (DO), concentration of carbon dioxide in an exhalation ($FeCO_2$), concentration of oxygen in the exhalation (FeO_2), pedagogical testing of special physical readiness.

Study design

Hypoxic training was conducted after having rest after the main training load. Hypoxic training was breathing in the closed space by the method of return breathing into the bag of Douglas to failure. Normobaric hypoxic training lasted 10 sessions of 10 series in each session. The duration of respiration in each serie was determined.

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Statistical analysis

Generalization of the studied characteristics was assessed by mean arithmetic value, standard deviation and error of mean arithmetic. Confidence of differences between mean values was stated by Student's t-criterion. Assessment of statistical hypothesizes based on 5% significance level. For statistical processing of data we used licensed program Microsoft Excel (2010). Statistical analysis of the received results was conducted, considering recommendations on Microsoft Excel tables' usage for computer data analysis. With the purpose of establishment of mechanisms of adaptation in providing of maximal possibility of the recurrent breathing the regressive analysis which determines the role of every factor in the hypoxic productivity was used in the reserved space. Application of incremental reverse regression enables to define the most meaningful factors in providing of adaptation to the hypoxic conditions.

Results of the study and their discussion

Preliminary testing of special physical preparedness has been made for determination positive influence of interval hypoxic training upon special capacity (table 1).

Table 1. Initial indicators of special physical readiness karate sportsmen of 16-17 years (n=18)

Tests	Experimental group (n=9)			Control group (n=9)		
	$\overline{X}$	σ	m	$\overline{X}$	σ	m
Static balance on the right foot, seconds	22,67	1,36	0,24	21,71	1,28	0,23
Static balance on the left leg, seconds	29,98	3,78	0,95	29,57	4,22	0,98
Dynamic balance with the right foot, seconds	18,55	1,42	0,24	19,75	1,45	1,17
Dynamic balance with the left foot, seconds	19,90	3,26	0,68	20,07	2,27	0,93
5 side impacts to the upper level by lifting the right foot, seconds	5,68	0,79	0,32	6,07	0,82	0,73
5 side impacts to the upper level by lifting the left foot, seconds	6,53	0,83	0,17	6,91	0,97	0,63
Side impacts with the right foot in the middle level for 10 seconds (quantity)	19,50	1,37	0,27	18,83	1,40	0,37
Lateral blows left foot in the middle level for 10 seconds (quantity)	17,85	1,13	0,32	16,71	2,47	0,35
Two hands and one side kick into the body of the leg 5 series, seconds	13,14	0,85	0,19	13,37	3,50	0,18
Counterattack attack, seconds	12,83	1,65	0,21	13,11	0,56	0,12

The analysis of the initial indicators of special physical preparedness indicates that in both groups they do not have statistically significant differences ($p>0,05$)

During the series of breathing in the confined space, this time was fixed, at which a certain frequency of respiration was maintained. Analysis of the results of the study indicates an explicit linear relationship between the duration of respiration in confined space and the increase in the index of $FeCO_2$ and the decrease in FeO_2 in the exhaled air (table 2). Thus, the duration of recurrent respiration at the beginning of the first series in the tenth session decreased by 93,33%. This was facilitated by the increase in $FeCO_2$ by 82,5%. It is characteristic that the tension of FeO_2 in the exhaled air after the tenth session decreased by 59,4%.

Table 2. Indicators of the oxygen transport system of karate sportsmen of 16-17 years at the beginning of hypoxic training (n=18)

T, min.	$FeCO_2$, %	FO_2, %	DO_2, litre	Breathing frequency, quantity	Respiration volume litre per min.	Heart beats per min.	Coefficient O_2, мl/per min.
7,50±0,03	2,80±0,03	19,30±0,07	0,66±0,01	10,50±0,09	8,64±0,02	65,00±0,70	32,30±1,40
7,30±0,07	5,20±0,01	17,00±0,04	0,62±0,04	19,00±0,08	9,87±0,01	71,20±0,71	33,70±0,90
5,60±0,03	5,30±0,02	15,30±0,01	0,63±0,07	19,30±0,07	10,93±0,03	71,00±0,90	35,50±0,70
4,00±0,06	6,10±0,01	14,20±0,04	0,60±0,03	18,60±0,04	11,40±0,05	74,30±1,10	31,40±0,40
3,10±0,02	6,30±0,04	14,00±0,01	0,58±0,01	17,20±0,03	11,38±0,07	82,10±1,03	29,50±1,11
2,60±0,01	6,70±0,02	13,80±0,04	0,62±0,08	19,10±0,04	11,55±0,03	94,50±1,12	30,30±0,70
2,20±0,03	7,20±0,02	13,00±0,08	0,60±0,04	20,00±0,07	12,16±0,02	100,10±1,43	29,10±0,90
1,80±0,02	7,40±0,03	12,40±0,08	0,58±0,05	28,30±0,05	13,14±0,05	105,20±1,32	26,60±0,70
1,70±0,03	7,60±0,02	12,10±0,09	0,56±0,07	20,10±0,06	13,50±0,05	107,50±0,97	26,10±1,10
0,70±0,04	7,80±0,01	11,80±0,07	0,55±0,03	20,40±0,07	13,50±0,07	108,50±1,22	27,00±1,20

It is worth noting that the increase frequency of heart beats (HB) is parallel to the indicators of pulmonary ventilation: frequency of heart beats (HB) by 65,2%, and the increase in pulmonary ventilation by 62,5%.

It is also established that the compensatory mechanism during recurrent respiration in the enclosed space is precisely of the increase in pulmonary ventilation and frequency of heart beats (HB). Conducting normobaric interval training for 10 sessions at the end of each mesocycle contributed to the increase in the level of special physical preparedness (table 3) and adaptive abilities of karate sportsmen of 16-17 years (table 4).

Table 3. Indicators of special physical preparedness of karate sportsmen of 16-17 years after exposure to hypoxic training (n=18)

Tests	Experimental group (n=9)			Control group (n=9)		
	$\overline{X}$	σ	m	$\overline{X}$	σ	m
Static balance on the right foot, seconds	47,50	2,36	0,89	24,81	4,22	0,94
Static balance on the left leg, seconds	48,30	3,78	1,52	34,19	2,87	1,09
Dynamic balance with the right foot, seconds	48,80	3,26	0,85	27,25	6,25	1,16
Dynamic balance with the left foot, seconds	99,90	5,72	0,84	30,72	4,45	1,19
5 side impacts to the upper level by lifting the right foot, seconds	5,18	6,26	0,12	6,14	7,32	0,13
5 side impacts to the upper level by lifting the left foot, seconds	5,50	7,16	0,11	6,53	5,73	0,14
Side impacts with the right foot in the middle level for 10 seconds (quantity)	20,70	6,45	0,31	18,90	9,82	0,27
Lateral blows left foot in the middle level for 10 seconds (quantity)	21,90	6,31	0,21	18,50	7,63	0,22
Two hands and one side kick into the body of the leg 5 series, seconds	12,31	3,75	0,07	13,12	5,87	0,09
Counterattack attack, seconds	4,16	3,81	0,08	4,89	4,17	0,08

Table 4. Indices of the reaction of the oxygen transport system karate sportsmen of 16-17 years after hypoxic training (n=18)

T, min.	$FeCO_2$, %	FO_2, %	DO_2, litre	Breathing frequency, quantity	Respiration volume litre per min.	Heart beats per min.	Coefficient O_2, мl/per min.
7,80±0,02	1,80±0,03	19,30±0,07	0,72±0,01	12,70±0,01	8,64±0,01	65,00±0,70	39,30±0,40
7,40±0,02	4,40±0,03	18,40±0,03	0,76±0,02	13,50±0,81	9,88±0,01	67,60±0,90	39,10±0,40
7,20±0,03	3,70±0,04	16,20±0,03	0,78±0,01	14,60±0,10	10,93±0,03	68,60±0,90	38,30±0,50
6,80±0,07	3,80±0,07	15,50±0,05	0,76±0,02	15,80±0,11	11,40±0,02	69,40±0,81	35,30±0,70
5,90±0,04	4,40±0,02	14,00±0,11	0,77±0,04	16,30±0,09	11,20±0,01	73,30±0,70	33,30±0,10
5,40±0,01	5,40±0,06	14,30±0,02	0,66±0,01	17,20±0,09	11,22±0,02	81,50±0,90	31,30±0,20
4,50±0,04	5,10±0,03	13,60±0,07	0,64±0,07	18,50±0,07	11,84±0,03	94,30±1,01	30,70±0,40
3,80±0,04	6,80±0,07	13,00±0,02	0,64±0,04	19,20±0,11	12,16±0,02	102,70±1,50	29,60±0,50
3,20±0,05	5,20±0,03	13,00±0,01	0,62±0,01	20,20±0,13	13,41±0,05	106,50±1,20	28,90±0,70
2,60±0,04	5,60±0,01	12,70±0,03	0,63±0,05	23,30±0,17	13,00±0,06	116,30±0,90	26,60±0,90

The indices of static and dynamic balance after sessions of hypoxic training increased by two ($p<0,001$). Shock movements were of particular interest, since the result of the match depends on their number and intensity. Thus, the time of execution of the strikes to the upper level by the right and left leg decreased by 89,4%, and the number of strokes in the middle level increased by 11,6 times ($p<0,001$).

During a duel judges determine the strongest and most accurate blows on the basis of which they give victory to one of the karate players. Net victory – the "ippon" score is given to the karate sportsmen: 1. for two clean kicks on the head; 2. for the technique carried out, on the opponent's body by hands or feet, after which the opponent cannot continue the fight; 3. for the technique carried out by kicking the opponent's legs and also if he cannot continue the fight. The floor of victory is given to the karate sportsmen: 1. for one clean kick with the feet on the head; 2. for the technique performed on the opponent's body by hands or feet, after which the opponent can continue the fight; 3. for the technique carried out by kicking the opponent's legs and also if he can continue the fight. The victory in a duel is determined by the preference of exact strikes. The art of their fulfillment depends on special anaerobic endurance.

Analysis of the results of the study (table 4) shows that the total duration of recurrent respiration in karate sportsmen of 16-17 years increased from 33,6 minutes at the beginning of the experiment to 54,6 minutes at the end ($p<0,001$).

The individual character of frequency of heart beats (HB), breathing frequency (FB), respiratory volume (DO) under the influence of hypoxic training reflects the articulated nature of the interaction of the respiratory and circulatory system. So, if the athletes have decreased $FeCO_2$, then there is the decrease HB.

Materials of the study testify that in the tenth series, the $FeCO_2$ index decreased in the tenth session by 28,3% compared to the first series, and the FeO_2 index increased by 35,6%.

The increase in anaerobic productivity contributed to the increase in competitive performance – the performance of accurate shocks. So, their number during the fight increased from 4,2±0,07 to 5,6±0,03 ($p<0,001$).

With the purpose of determining the mechanisms of hypoxic adaptation of the organism of karate sportsmen of 16-17 years, a regression analysis method was used that establishes the role of each indicator of the oxygen transport system in providing hypoxic performance. The presented mathematical models show the interaction of intersystem and intrasystemic connections in the regulation of the duration of recurrent respiration. So, after the first series of hypoxic training (formula 1) shows the significance and interrelation of the factors of the cardiorespiratory system of karate sportsmen of 16-17 years.

$$T_{min1}=4,57xFB+3,58xFB_{T\ exhalation}+3,39xHB-1,75xCO\ O_2-1,37xDO+$$
$$+1,05xFeCO_2+2,15xFeO_2+0,92xLV+0,17xFB_{T\ inhalation}\ \text{(formula 1)}$$

where T_{min1} is duration of the recurrent breathing in the first session; FB is breathing frequency; $FB_{т\ exhalation}$ is the volume of the forced exhalation; HB is frequency of heart beats; DO is the respiratory volume; CO O_2 is the coefficient of the use of oxygen; $FeCO_2$ is the concentration of carbon dioxide in an exhalation; FeO_2 is the concentration of oxygen in the exhalation; LV is the vital capacity of lungs; $FB_{т\ inhalation}$ is a volume of the forced inhalation.

To determine the most significant indicators in ensuring the duration of recurrent respiration in the closed space, the inverse step regression method was used, which determined the most regular factors (formula 2).

$$T_{min1}=5,63xFB+5,37xFB_{т\ exhalation}+3,93xHB \text{ (formula 2)}$$

where T_{min1} is duration of the recurrent breathing in the first session; FB is breathing frequency; $FB_{т\ exhalation}$ is the volume of the forced exhalation; HB is frequency of heart beats.

In the process of research, it is very important to establish the level of competitive performance – the number of accurate hits in at one and a half minute fight and on what factors this performance depends.

The resulted mathematical models of regression analysis show the significance level of each factor in achieving the sporting result (formula 3).

$$Indk_1=4,75xT_{min1}+6,39xDO+3,75xFB+2,57xHB–2,73xCO\ O_2–1,73x$$
$$xFB_{т\ exhalation}+1,65FeO_2+3,05xFeCO_2+2,17xLV+0,97xFB_{т\ inhalation} \text{ (formula 3)}$$

where $Indk_1$ is the number of accurate shocks; T_{min1} is the duration of recurrent respiration; DO is the respiratory volume; FB is breathing frequency; HB is the frequency of heart beats; CO O_2 is the coefficient of the use of oxygen; $FB_{т\ exhalation}$ is the volume of the forced exhalation; FeO_2 is the concentration of oxygen in the exhalation; $FeCO_2$ is the concentration of carbon dioxide in an exhalation; LV is the vital capacity of lungs; $FB_{т\ inhalation}$ is the volume of the forced inhalation.

Applying the inverse step regression formula, the most important factors in ensuring the competitive activity of karate sportsmen of 16-17 years of precise shocks (formula 4) are established.

$$Indk_1=6,93xT_{min1}+5,27xFB_{т\ exhalation}+3,35xHB \text{ (formula 4)}$$

where $Indk_1$ is the number of accurate shocks; T_{min1} is the duration of recurrent respiration; $FB_{т\ exhalation}$ is the volume of the forced exhalation; HB is the frequency of heart beats.

Thus, the mechanism of hypoxic performance is limited by the state of the functional activity of the oxygen transport system.

Conduction of hypoxic training in the form of recurrent respiration into confined space promoted a significant increase in the adaptability of karate sportsmen of 16-17 years to the conditions of anaerobic motor activity. The multiple regression equation determined this kind of interrelation of cardiorespiratory parameters that ensure the duration of recurrent respiration in the closed space (formula 5).

$$T_{мin2}=6,73xFB_{т\ exhalation}+6,21xFB+5,45xDO+3,47xHB+3,15xFeCO_2–$$
$$–2,75xLV+6,32xCO\ O_2+2,15xFeO_2+1,74x\ FB_{т\ inhalation} \text{ (formula 5)}$$

where $T_{мin2}$ is duration of the recurrent breathing in the tenth session; $FB_{т\ exhalation}$ is the volume of the forced exhalation; FB is breathing frequency; DO is the respiratory volume; HB is frequency of heart beats; $FeCO_2$ is the concentration of carbon dioxide in an exhalation; LV is the vital capacity of lungs; CO O_2 is the coefficient of the use of oxygen; FeO_2 is the concentration of oxygen in the exhalation; $FB_{т\ inhalation}$ is the volume of the forced inhalation.

The stepwise regression regression equation determined three main factors in ensuring the duration of recurrent karate sportsmen of 16-17 years in the tenth session (formula 6).

$$T_{мin2}=5,36xCO\ O_2+4,85xFB_{т\ exhalation}+3,85xFB_{т\ inhalation} \text{ (formula 6)}$$

where $T_{мin2}$ is duration of the recurrent breathing in the tenth session; CO O_2 is the coefficient of the use of oxygen; $FB_{т\ exhalation}$ is the volume of the forced exhalation; $FB_{т\ inhalation}$ is the volume of the forced inhalation.

After the tenth session of the final tenth series of hypoxic training, the regression analysis equation indicates that the adaptive mechanism for providing competitive activity has changed somewhat. This allows us to determine new, more significant factors in achieving the number of determinants of accurate shocks (formula 7).

$$Indk_1=6,75xT_{мin2}+5,79xFB_{т\ inhalation}+4,37xFB_{т\ exhalation}+3,95xCO\ O_2+3,25xFB+$$
$$+2,95xHB–1,75xFeCO_2+2,73xFeO_2+1,95xLV+2,03xDO \text{ (formula 7)}$$

where $Indk_1$ is the number of accurate shocks; $T_{мin2}$ is duration of the recurrent breathing in the tenth session; $FB_{т\ inhalation}$ is the volume of the forced inhalation; $FB_{т\ exhalation}$ is the volume of the forced exhalation; CO O_2 is the coefficient of the use of oxygen; FB is breathing frequency; HB is frequency of heart beats; $FeCO_2$ is the concentration of carbon dioxide in an exhalation; FeO_2 is the concentration of oxygen in the exhalation; LV is the vital capacity of lungs; DO is the respiratory volume.

The inverse step regression equation defines the three main factors in providing competitive performance (formula 8).

$$Indk_1=7,22xT_{мin2}+5,17xHB+3,75xFB_{т\ inhalation} \text{ (formula 8)}$$

where $Indk_1$ is the number of accurate shocks; $T_{мin2}$ is duration of the recurrent breathing in the tenth session; HB is frequency of heart beats; $FB_{т\ inhalation}$ is the volume of the forced inhalation.

Thus, the conducted studies of the influence of hypoxic normobaric training indicate that with increasing hypoxic stability, the effectiveness of the competitive activity of karate sportsmen of 16-17 years is significantly increased.

Discussion

Considering the problem of training karate sportsmen of 16-17 years, it was established that in the process of physical training it is necessary to solve problems specific this sport [2, 6, 7].

The structure of physical preparedness, as a complex, multifactor indicator, was considered in many sports [11, 27, 30].

In accordance with the studies [12, 13, 20], it is established that there are single studies of this problem in the preparation of karate sportsmen who do not create an idea of the versatility of individual components of special physical preparedness and the role of each of them in the formation of complexly coordinated techniques.

Karate, as sport, is characterized by intensive motor activity, which is carried out under anaerobic conditions of submaximal intensity. It is proved that the manifestation of speed-strength endurance depends on hypoxic adaptability [20, 26].

At the same time, there are no research works that consider complex adaptive patterns in the process of karate training in conditions of normobaric hypoxia. Combining hypoxic effects with modification of physical loads allows to significantly improve the process of controlling the training of athletes in sports of submaximal intensity [3, 6, 8].

Adaptation mechanism to hypoxic hypercapnia is the complex integral reaction in which intrasystemic and intersystem rebuilding of the organism is manifested, which causes the special working capacity [9, 14, 18].

Studies [16, 28, 29] indicate that the achievement of high results in sports with a coordinated orientation of submaximal intensity depends on the rate of gas exchange in the lungs and the delivery of oxygen by blood to working muscles [15, 16, 17, 28].

In our studies, it was shown that in the initial stages of the hypoxic training of karate sportsmen aged 16-17, the increase in $FeCO_2$ in the exhaled air is a stimulator of lung ventilation, which is accomplished by increasing the respiratory rate with a slight decrease in the depth of breathing [21, 23, 24, 25, 28]. Later it was established that the achievement of the competitive activity of the karate sportsmen of 16-17 years of $Indk_2$ depends on the three main factors of hypoxic preparedness: the total respiration time in the closed space (T_{min2}); frequency of heart beats (HB), volume of the forced inhalation ($FB_{г\ inhalation}$).

Conclusions

The analysis of the literature data made it possible to determine the general patterns of adaptation of the human body to the conditions of interval normobaric hypoxia, to determine which functional systems provide an adaptive effect and how the level of hypoxic adaptability contributes to a special sports performance.

An example of karate shows the important role of hypoxic stability in martial arts. The developed method of hypoxic training with the method of recurrent breathing allows us to determine the most important factors in raising the level of special physical fitness of karate sportsmen aged 16-17 and the most important factors of the oxygen transportation system in achieving the result.

Acknowledgements

This study was carried out in the scope of «Perfection control of sportsmen moving activity mechanisms» according to summary plan in the sphere of scientific investigated work of Physical Culture and Sports of ministry education of Ukraine on 2016-2020 years.

References

1. Akopyan A.O. (2008). Express assessment of the level of functional reserve training in martial arts. *Herald of sports science*, 4, 10-12.
2. Ashanin, V.S. and Pyatisotskaya, S.S. (2007). Individualization of the training process of karate as on the basis of information modeling of various aspects of the preparedness of athletes. *Physical Education of the Student of Creative Specialties*, 1. 7-13.
3. Bailey, D., Davies, B. and Baker, J. (2000). Training in hypoxia: modulation of metabolic and cardiovascular risk factors in man. *Medicine and Science in Sports and Exercise,* 32(6), 1058-1063.
4. Baranov, M.V. and Malyarenko, A.T. (2009). Structure component technology competitive activities of high-class athletes in karate. *Slobozhanskiy scientific-sports visnik,* 1, 93-95.
5. Bernardi, L., Passino, C. and Wilmerding, V. (2001). Breathing patterns and cardiovascular autonomic modulation during hypoxia induced by simulated altitude. J. Hypertens, 19(5), 947-952.
6. Boychenko, N.V. (2009). Analysis of serious technology during the competition federation in "Kyokushinkai" karate. *Physical Education of the Student of Creative Specialties*, 1, 11-18.
7. Boychenko, N.V. (2010). Perfection of technique-tactic skill and speed possibilities of caratists of the style «Kyokushinkai». *Pedagogics, psychology and medical-biologic problems of physical education and sport*, 2, 27-30.

8. Dinesenko, U. P. (2005). Mechanisms of urgent adaptation of sportsmen to influences of the physical loading. *Theory and practice of physical cultures*, 3, 14-17.
9. Draper, S. B. and Wood, D. M. (2005). The VO_2 response for an ex haustile tveadmill rsn at 800 m race: a breathly analysis. *Eur J Appl Physiol*, 93, 381-389.
10. Galimskyi, V.A. (2012). Condition of physical development and physical ftness of young karate on stage forming experiment. *Pedagogics, psychology and medical-biologic problems of physical education and sport*, 11, 23-26.
11. Galimskyi, V.A. (2014). Modeling of physica ftness of young karatyst on the prebasic training. *Pedagogics, psychology and medical-biologic problems of physical education and sport*, 9, 17-23.
12. Heikki Rusko, Heikki Tikkanen & Juha Peltonen (2004). Altitude and endurance training. *Journal of Sport Science*, 22, 928-945.
13. Hirokazu Kanazava (1994). Karate fighting techniques the complete kumite. *Kodansha international Ltd,* 192-196.
14. Hochachka, P.W., Rupert, J.I. & Monge C. (1999). Adaptation and conservation of physiological system in the evolution of human hypoxia tolerance. *Comp. Biochem. Physiol*, 124, 1-8.
15. Iermakov, S., Podrigalo, L., Romanenko, V., Tropin, Y., Boychenko, N. and et.al. (2016). Psycho-physiological features of sportsmen in impact and throwing martial arts. *Journal of Physical Education and Sport*, 16 (2), 433-441.
16. Kolchinskaya, A. Z., Tsiganova, T. N. and Ostapenko, L. A. (2003). Normobaristic interval hypoxic training in medicine and sport. *Medicine*, 208.
17. Loeppky, J. A., Icenogle, M. and Scotto, P. (1997). Ventilation during simulated altitude, normobaric hypoxia and normoxic hypobaria. *Respir Physiol*, 107(3), 231-235.
18. Olivier Girard, Frank Brocherie, Jean-Benoit Morin & Gregory P. Millet (2016). Running mechanical alterations during repeated treadmill sprints in hot versus hypoxic environments. *A pilot study, Journal of Sport Science*, 34 (12), 1190-1198.
19. Platonov, V.N. (2004). System of sportsmen's preparation in olympic sports. *Olympic literature*, 807.
20. Ralph, B., Thorsten, B. and Christop, J. (2004). Energetics of karate kumite. *Eur j Physiologyh*, 518-528.
21. Rovnaya, O. A. and Ilyn, V. N. (2010). Features of adaptive reactions of the respiration system of highly skilled of the synchronous swimming sportswomen during the integral hypoxic training (IHT). *Pedagogics, psychology and medical-biologic problems of physical education and sport*, 9, 71-75.
22. Rovniy Anatoly Stepanovitch, Pasko Vladlena Vitaliivna and Grebeniuk Oleg Viktorovich (2016). Adaptation of reformation of physiological functions of the organism of the 400 m hurdlers during hypoxic training. *Journal of Physical Education and Sport*, 16 (4), 1340-1344.
23. Rovniy Anatoly, Pasko Vladlena, Stepanenko Dmytro and Grebeniuk Oleg (2017). Hypoxic capacity as the basis for sport efficiency achievements in the men's 400-meter hurdling**.** *Journal of Physical Education and Sport*, 17 (1), 300-305.
24. Rovniy Anatoly, Pasko Vladlena, Martyrosyan Artur (2017). Adaptation of the cardioresphiratory system to hypoxic actions of the rugby players depending on the playing position. *Journal of Physical Education and Sport*, 17 (2), 804-809.
25. Rovniy, A. S. and Rovniy, V. A. (2009). Management the system of preparation of young runners of the 400 m hurdlers. *Slobozhanskiy scientific-sports visnik*, 3, 72-75.
26. Rovniy, A. S., Galimskyi, V.A., and Boychenko, N.V. (2016). Physical and technical-tactical training of karatekists (Kyokushinkai) at the stage of preliminary basic training, *Monograph*, 247.
27. Skowinska, L. M. & Majda, J. (2002). Hormone plasma levels from pituitarygonadol axis in performance athletes after the 400 m run. *Jornal of Sports Medicine and Physical Fitnes, Toino*, 42(2), 243-249.
28. Sybil, M. G. & Svysch, Y.S. (2009). State of energy providing systems of athletes-sprinters in the conditions of artificial hypoxia. *Pedagogics, psychology, medical-biological problems of physical training and sportsf*, 7, 178-183.
29. Ulmer, H.-V., Macsenaere, M. & Valasiadis, A. (1999). Psychophysiologische Erholung nach linem 400-lauf-Vergleich zwier objektiver und zweier subjective test [Psychophysiological recovery following a 400 m race comparison of two objective and two subjective tests*]. Psychology und sport, schorndorf,* 6, 12-17.
30. Volkov, N. I., Biryuk, S. V. and Saveliev, I. A. (2002). An oxygen request and energy expenses of tense muscular activity. *Physiology of man*, 4, 80-93.