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Dynamics of Respiratory System Indices of Cadets of Higher Military Educational Institutions During Kettlebell Lifting Training

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ABSTRACT
The influence of the kettlebell lifting training on the functional abilities of the respiratory system of the cadets during studying at higher military educational institutions (HMEI) is examined in the article. Also, a comparative analysis of the indices of the cadets' respiratory system depending on their sports qualification in kettlebell lifting is conducted. Cadets of the 1st – 5th years of study (n=474) of S. P. Koroliov Zhytomyr Military Institute who were studying according to the current system of physical training (group A, n=416) and cadets who were attending a kettlebell lifting classes during the studying (group B, n=58) took part in the investigation. The investigation of the cadets' respiratory system efficiency was conducted concerning these indicators: vital capacity, duration of holding of breathing during the inhalation, duration of holding of breathing during the exhalation, respiratory muscles endurance, life index and maximal oxygen consumption. Authentically better respiratory system indices in group B in comparison with group A are discovered ($p < 0.05–0.001$) that proves the efficiency of kettlebell lifting activity concerning the improvement of morphofunctional development of the cadets in contrast to the current system of physical training at HMEI. The respiratory system indices are improved with increased sports qualification of kettlebell lifters that confirms the positive effect of kettlebell lifting activity on the functional capacity of the main organism systems of cadets. Investigation shows the necessity of the implementation of kettlebell lifting to the physical training of the cadets who are the future Ukrainian Armed Forces' officers in order to ensure high efficiency of the future professional activity, improve health and working capacity.

1. Introduction

Modern professional military (combat) activity of the higher military educational institutions` graduates – Ukrainian Armed Forces` future officers takes place under extreme conditions of the external environment, physical and mental load, growing exhaustion and other unfavorable factors [8, 16]. Combat conditions demand military servicemen to be stress resistant, have highly-developed physical and volitional powers, military applied motor skills and also enough spare physiological capacities of an organism [6, 11]. Concerned demands are implemented in the system of physical training which is an essential part of the combat training of military servicemen and is aimed to ensure physical readiness of troops to perform the tasks by designation [7, 8]. Additionally, the traditional system of physical training does not ensure the future officers` formation of readiness to combat activity to the full extent because of the low level of physical fitness and health of the youth entering higher military educational institutions and other reasons [6, 7, 11].

One of the efficient means of cadets' physical training is kettlebell lifting [3, 14, 19]. In contrast to other military applied kinds of sport, the privileges of kettlebell lifting are the absence of considerable expenses, compactness of the equipment, intelligibility and simplicity of the exercises, possibility to carry out training in any time and place, alone and with a group, for military servicemen of different level of physical fitness, high efficiency concerning physical and volitional powers development, prevention of spinal injuries and joint damages [4, 13]. The essence of kettlebell lifting is to lift a kettlebell of definite weight as many times as you can for the period of time determined by the competition policy. Modern competitions include exercises limited to 10 or 12 minutes [13]. In biathlon sportsmen perform two exercises both lasting for 10 minutes. According to the scientists' data [2, 9], which describe the physiological characteristics of kettlebell lifting, sportsmen lift more than 10 tons for 10 minutes just in one exercise in kettlebell lifting and the organism's oxygen demand is quite big. The scientists equate competing work in kettlebell lifting with

overcoming the distance in 10-15 km in cross-country skiing regarding energy demands [6, 14, 15]. The scientists [17, 18] mention that weight lifting advances high demands for the sportsmen's cardiorespiratory system and denote that the results in kettlebell lifting is in the correlation ratio of the indicators of step-test, duration of holding of breathing during the inhalation and 3 km race that means high functionality of the respiratory and other systems of the kettlebell-lifters organisms. Any respiratory rhythm disturbance during the exercises with kettlebells causes oxygen starvation and premature exhaustion that influences the general results negatively. The conducted analysis of the literature sources proves that kettlebell lifting has a positive influence on the functional capacity of the cadets` respiratory system that will ensure the improvement of the officers` health and combat activity efficiency in the future. Therefore, the modern political and military situation in Ukraine actualizes scientific problems connected with the searching of the ways of physical training improvement of the cadets – future Ukrainian Armed Forces` officers.

The aim of study is to investigate the influence of the kettlebell lifting training on the efficiency of the cadets' respiratory system functioning during studying.

2. Method

2.1. Participants

Cadets of the 1st – 5th years of study (n=474) of S. P. Koroliov Zhytomyr Military Institute who were studying according to the current system of physical training (group A, n=416) and cadets who were attending a kettlebell lifting classes during the studying (group B, n=58) took part in the investigation. To investigate the respiratory system indices of the cadets attending a kettlebell lifting classes depending on the qualification the group B was divided into three groups: group №1 – the cadets who have the 3rd and the 2nd grades in kettlebell lifting (n=26), group №2 – the cadets who have the 1st grade and Candidates in Masters of Sport (n=21), group №3 – the cadets who are Masters of Sport and Masters of Sport of International Class (n=11).

2.2. Materials

The investigation of the cadets' respiratory system efficiency was conducted concerning these indicators: vital capacity, duration of holding of breathing during the inhalation, duration of holding of breathing during the exhalation, respiratory muscles endurance, life index (which is the ratio of vital capacity to body weight) and maximal oxygen consumption [10, 12, 20, 21]. The vital capacity was measured with the help of lung tester. To test the duration of holding of breathing during the inhalation and exhalation (timed inspiratory and expiratory capacities) the cadets, having remained seated, inhaled three times to the three-fourths depth and held their breath holding nose with fingers. The examination of the timed inspiratory capacity was conducted according to the standards: excellent result – more than 60 s, good – 40-60 s, adequate – 30-40 s, inadequate – less than 30 s. The results in the timed expiratory capacity were evaluated in the next way: excellent – more than 40 s, good – 30-40 s, adequate – 25-30 s, inadequate – less than 25 s. The examination of the respiratory muscles endurance (Rosenthal's test) included the vital capacity test carried out 5 times every 15 s. If the amount of the exhaled air is decreased after the 5th time, it means the deterioration of the functional capacities of the respiratory system (or its exhaustion, overstrain, overwork, disease). If the amount of the exhaled air remains the same, it means the satisfactory condition of the respiratory system. If the amount of the exhaled air is increased, the endurance of the respiratory muscles is rated as excellent and the efficiency of the system is improved. The life index equals the ratio of vital capacity to body weight and it was evaluated in the next way: the high level of the respiratory system functioning – 66 ml/kg and more, above the average level – 61-65 ml/kg, the average level – 50-60 ml/kg, below the average level – 51-55 ml/kg, the low level – 50 ml/kg and less. Maximal oxygen consumption (MOC) was measured by applying the indirect method, physical working capacity test (PWC_{170}) according to the formula $MOC = 2.2 \cdot PWC_{170} + 1070$. To measure PWC_{170} the cadets were carrying out two sets on the stationary

bicycle both lasting for 5 minutes (tempo – 60 revolutions per minute) with 3-minutes break between them. The investigation of the cadets' respiratory system indices was conducted in the medical unit of S. P. Koroliov Zhytomyr Military Institute during a yearly standard medical examination by medical staff in the afternoon.

During the researches the authenticity of difference between the indices of cadets of groups A and B by means of Student's criterion was determined. The dynamics of indices in each of groups was also estimated. The significance for all statistical tests was set at $p < 0.05$.

Researches related to the involvement of cadets were carried out in compliance with all relevant national regulations and institutional policies (Order of the Minister of Defense of Ukraine «On Approval of the Regulation on the Organization of Scientific, Scientific and Technical Activities in the Armed Forces of Ukraine» dated 27.07.16, No. 385), and also the principles of the Helsinki Declaration of the World Medical Association. Informed agreement was received from all people involved in this research.

3. Results

The results of the examination of the kettlebell lifting influence on the functional abilities of the respiratory system of the cadets during studying are presented in Table 1.

Vital capacity – the maximal amount of the exhaling air after taking a deep breath – shows the state of the organs of external respiration. Therefore, the analysis of the vital capacity proves that the authentic difference in the indices of the respiratory system of the cadets from group A and B in the 1st years of study is not discovered ($p > 0.05$). The authentic influence of the kettlebell lifting on the vital capacity is discovered in the cadets of the last years of study: in the 3rd year of study, the results of group B are 238.1 ml better than the results of group A authentically ($p < 0.05$), in the 4th year of study – 358.1 ml better ($p < 0.01$), in the 5th year of study – 323 ml better ($p < 0.01$). The investigation of the vital capacity dynamics proved that the indices of the respiratory system are improved in both groups during the study ($p < 0.05$–0.01), but the difference in the indices of the respiratory system in the 5th and the 1st years of study is 196.1 ml in group A and 598.6 ml in group B that proves positive effect of the kettlebell lifting on the functional abilities of the respiratory system.

Table 1. *The dynamics of the respiratory system indices of the cadets who were studying according to the current system of physical training (group A) and cadets who were attending a kettlebell lifting classes (group B), n=474*

Years of study	Group A (n=416)		Group B (n=58)		Significance value
	n	X±m	n	X±m	
Vital capacity, ml					
1	62	4092.0±63.38	16	4012.5±120.03	$p > 0.05$
2	112	4142.1±50.17	9	4255.6±105.56	$p > 0.05$
3	91	4190.5±53.52	14	4428.6±94.01	$p < 0.05$
4	76	4227.6±58.36	12	4585.7±98.17	$p < 0.01$
5	75	4288.1±54.61	7	4611.1±103.35	$p < 0.01$
p1 – p5	$p < 0.05$		$p < 0.01$		
Duration of holding of breathing during the inhalation, s					
1	62	58.9±1.88	16	60.2±2.79	$p > 0.05$
2	112	62.0±1.32	9	65.9±3.43	$p > 0.05$
3	91	68.9±1.61	14	73.5±2.94	$p > 0.05$
4	76	71.8±1.76	12	80.8±3.01	$p < 0.05$
5	75	72.3±1.82	7	88.3±4.17	$p < 0.05$
p1 – p5	$p < 0.001$		$p < 0.001$		
Duration of holding of breathing during the exhalation, s					
1	62	38.5±0.78	16	39.1±1.60	$p > 0.05$
2	112	40.4±0.61	9	42.6±1.85	$p > 0.05$
3	91	41.8±0.69	14	45.5±1.68	$p < 0.05$

4	76	43.0±0.72	12	47.7±1.71	$p < 0.05$
5	75	43.2±0.75	7	49.8±2.13	$p < 0.01$
p1 – p5	$p < 0.001$		$p < 0.001$		
Life index, ml/kg					
1	62	56.75±0.85	16	55.81±1.90	$p > 0.05$
2	112	56.20±0.69	9	58.94±2.31	$p > 0.05$
3	91	55.72±0.72	14	61.94±1.94	$p < 0.01$
4	76	55.77±0.77	12	63.60±1.96	$p < 0.01$
5	75	55.76±0.82	7	63.61±2.18	$p < 0.01$
p1 – p5	$p > 0.05$		$p < 0.05$		

The examination of the timed inspiratory capacity showed no authentic differences in the results of the cadets of both groups A and B in the 1st – 3rd years of study ($p > 0.05$), although the cadets from group B had 3.9 s better average results in the timed inspiratory capacity than the cadets of group A in the 2nd year of study and 4.6 s better in the 3rd year of study. The authentically better results in the timed inspiratory capacity are discovered in group B in comparison to group A, the difference is 9.0 s in the 4th year of study and 16 s in the 5th year of study ($p < 0.05$). Having compared the results in the timed expiratory capacity, we determined that the cadets attending kettlebell lifting classes started to have better results than the cadets who were studying according to the current system of physical training at HMEI in the 3rd year of study. Therefore, the difference in the results of the cadets from group A and B is 3.7 s in the 3rd year of study ($p < 0.05$), 4.7 s – In the 4th year of study ($p < 0.05$) and 6.6 s – in the 5th year of study ($p < 0.01$). The analysis of the trend of these results proves the authentic improvement of the cadets` of both groups timed inspiratory and expiratory capacities ($p < 0.001$). However, the difference in the results in timed inspiratory and expiratory capacities of the cadets of the 1st and 5th years of study is 13.4 s and 4.7 s in group A and 28.1 s and 10.7 s in group B respectively.

The conducted analysis shows that kettlebell lifting activity has more efficient influence on the improvement of the future officers` respiratory system activity in comparison to the current system of physical training at HMEI. According to the table of grading of results in the timed inspiratory and expiratory capacities, the level of functional abilities of cardiovascular and respiratory systems of cadets from both groups is started to rate as excellent in the 2nd year of study.

The analysis of the life index showed no authentic differences in the results of the cadets from both group A and B in the 1st and the 2nd years of study ($p > 0.05$). The cadets who were attending a kettlebell lifting classes have 6.22 ml/kg better life index than the cadets who were studying according to the current system of physical training in the 3rd year of study authentically ($p < 0.01$), 7.83 ml/kg – In the 4th year of study ($p < 0.01$) and 7.85 ml/kg – in the 5th year of study ($p < 0.01$). The examination of the changes of the life index during the studying shows the negative dynamic of the index in group A – the results of the cadets of the 5th year of study are 0.99 ml/kg worse than in the 1st year of study ($p > 0.05$). The uptrend in the life index is observed in group B during the studying. Therefore, the life index results are the best in the 5th year of study (63.61 ml/kg) and 7.80 ml/kg better in comparison to the results in the 1st year of study authentically ($p < 0.05$). According to the table of grading, the indices of the life index are rated as average in group A in every year of study and the level of the functional abilities of the respiratory system of the cadets from group B are rated as average in the 1st and the 2nd years of study and as above the average in the last years of study that proves the prior conclusions concerning the positive influence of kettlebell lifting on the indices of the cadets` respiratory system activity. The analysis of the life index distribution of the cadets of different years of study proves that the number of the cadets who have life index rates as above the average and high is increased every year – In the 5th years of study, the quantity of these cadets is 42.8 % and 28.6 % respectively (Table 2). In the 5th year of study, no cadets who are attending a kettlebell lifting classes and have the low or below the average level of the functional abilities of the

respiratory system are discovered. In group A, almost stable life index distribution of the cadets and an inconsiderable increase of the cadets who have life index rated as below the average in the last years of study are observed (49.5 %, 51.3 % and 50.6 % respectively).

Table 2. *The life index distribution of the cadets from group A and B, %*

Years of study	Group A (n=416)						Group B (n=58)					
	Levels of the life index											
	n	L	BA	A	AA	H	n	L	BA	A	AA	H
1	62	14.5	40.4	30.6	9.7	4.8	16	12.5	18.8	56.2	12.5	-
2	112	8.9	43.8	32.1	9.8	5.4	9	11.2	22.2	44.4	22.2	-
3	91	8.8	49.5	25.3	10.9	5.5	14	7.1	14.3	35.7	35.7	7.1
4	76	6.6	51.3	25.0	10.5	6.6	12	-	8.3	16.7	50.0	25.0
5	75	2.7	50.6	30.8	9.3	6.6	7	-	-	28.6	42.8	28.6

N o t e. L – the low level, BA – below the average level, A – the average level, AA – above the average level, H – the high level.

To determine the influence of kettlebell lifting on the functional abilities of the cadets` respiratory system concerning the level of their kettlebell lifting qualification we examined the indices of the kettlebell lifters of different sports qualification (three groups) (Table 3). The analysis of the vital capacity of the kettlebell lifters of different qualification showed that the higher qualification a cadet has, the more level of vital capacity is increased – the cadets from group №3 are discovered to have the best results (4897.2 ml). This result is 411.7 ml and 836.5 ml better authentically than the results in groups № 2 and № 1 respectively ($p < 0.01$; $p < 0.001$) that shows the informative value of this indicator and the necessity to consider it in the process of cadets` kettlebell lifting training. The examination of the results in the respiratory muscles endurance proves that the indices of vital capacity are 148.4 ml decreased in group № 1 authentically ($p > 0.05$), almost not changed in group № 2 (the difference is 78.3 ml, $p > 0.05$) and 16.1 ml increased in group № 3 ($p > 0.05$). It proved that the higher sports qualification in kettlebell lifting the cadets have, the better results in respiratory muscles endurance they achieve. Furthermore, the results of the cadets from group № 3 in vital capacity after the respiratory muscles endurance test are better authentically in comparison to groups with the cadets of lower qualification ($p < 0.01$; $p < 0.001$). The more thorough analysis of the results in the respiratory muscles endurance showed that 86.3 % cadets from group № 3 had 2-5 % better results in vital capacity after the test than at the beginning of the examination; there are 35.2 % such cadets in group № 2; and 94.8 % cadets from group № 1 have decreased results. The conducted investigation proves the respiratory muscles endurance increase and cardiorespiratory system efficiency improvement with their increase of qualification in kettlebell lifting.

Table 3. *The level of the functional abilities of the respiratory system of the cadets who have different sport qualification in kettlebell lifting (n=58)*

The examined indicators	Group № 1	Group № 2	Group № 3	Significance value		
	n=26	n=21	n=11	p1-p2	p2-p3	p1-p3
Vital capacity, ml	4060.7±79.25	4485.5±71.42	4897.2±113.5	< 0.01	< 0.01	< 0.001
Respiratory muscles endurance, ml	3912.3±84.22	4407.2±75.39	4915.3±115.6	< 0.001	< 0.01	< 0.001
Timed inspiratory activity, s	64.7±3.20	80.8±3.92	96.5±3.66	< 0.01	< 0.05	< 0.001
Timed expiratory activity, s	39.8±1.64	46.9±1.58	57.1±1.76	< 0.01	< 0.001	< 0.001
Maximal oxygen consumption, ml/min	3477.4±76.54	3920.5±69.83	4318.5±79.76	< 0.01	< 0.01	< 0.001

Maximal oxygen consumption/kg, ml/min/kg	48.6±1.53	53.7±1.47	62.3±1.60	< 0.05	< 0.01	< 0.001

The functional timed inspiratory and expiratory activities are generalized indicators of the respiratory and cardiovascular systems and they characterize the organism's resistance to the lack of oxygen. The more long-lasting breath holding is the better functional abilities these systems have. The analysis of the results in the timed inspiratory activity shows that the cadets who have a high qualification in kettlebell lifting have the higher level of the functional abilities of the respiratory system than the cadets who have different grades in kettlebell lifting and the cadets of low qualification authentically ($p < 0.05–0.001$). The difference in the results in the timed inspiratory activity of the cadets from groups № 1 and № 2 is 16.1 s ($p < 0.01$), groups № 2 and № 3 – 15.7 s ($p < 0.05$), and groups № 1 and № 3 – 31.8 s ($p < 0.001$). The results of the examination of the kettlebell lifters in the timed expiratory activity have similar trend – the cadets from group № 3 have the best results (57.1 s) which are 17.3 s and 10.2 s better authentically than the results of the kettlebell lifters from groups № 1 (39.8 s) and № 2 (46.9 s) respectively ($p < 0.001$).

The analysis of the maximal oxygen consumption proved its authentic improvement with increased qualification of cadets – the cadets of high qualification are discovered to have the best result – 4318.5 ml/min which is 398 and 841.1 ml/min better authentically than the results of the cadets from group № 2 (3920.5 ml/min) ($p < 0.01$) and № 1 (3477.4 ml/min) ($p < 0.001$) respectively. The maximal oxygen consumption/kilogram (MOC/kg) is 48.6 ml/min/kg in group № 1 and it is 5.1 ml/min/kg worse than the result of the cadets from group № 2 (53.7 ml/min/kg) authentically ($p < 0.05$) and 13.7 ml/min/kg worse than the result of the cadets from group № 3 (62.3 ml/min/kg) ($p < 0.001$).

4. Discussion

The research [2, 9, 6, 19] mentions that kettlebell lifting is among the exercises with the cyclical pattern of high relative capacity and determines that the physical capacity of the kettlebell lifters of high qualification equals to the work capacity of bike riders, skiers, runners and boaters. The scientists [4, 13, 14, 15, 17] report the next characteristics of the loads with which kettlebell lifting provides: heart rate – 180-210 beats per minute, oxygen consumption – 90-95 % of maximum, predominant nature of work – aerobically anaerobic, oxygen debt – to 12 liters with highly increased level of lactic acid in blood, the respiratory system work – maximal, the work of the heart – submaximal. The main physiological functions of an organism that affect the results in kettlebell lifting: metabolism which should occur when an organism gets enough oxygen and removes breakdown products (that emphasize the importance of the rational process of breathing and development of the respiratory system); coordination of muscle tension and relaxation of muscles (enough blood supply of working muscles is possible only in the period of their relaxation when blood vessels are free from the muscles pressure and venous bloodstream removes breakdown products from the body) [1, 5, 10, 21]. Therefore, the achievements in kettlebell lifting require of sportsmen the high level of development of the respiratory system indices that means the positive influence of kettlebell lifting on the functional abilities of the cadets' respiratory system. This hypothesis was confirmed by the results of conducted research. The analysis showed that all indices of the respiratory system of the cadets who were attending a kettlebell lifting classes are discovered to be better than the indices of the cadets who were studying according to the current system of physical training in the last years of study authentically ($p < 0.05–0.001$). The research proves that kettlebell lifting has great influence on the improvement of the indices of the functional abilities of the main systems of an organism (in particular the respiratory system) during the studying – the kettlebell-lifters are discovered to have the best indices in the 5th year of study. Concerning the conducted characteristics, the indices of the cadets who were attending a kettlebell lifting classes are better than the indices of the cadets who were studying according to the current system of physical training at HMEI in the last years of study authentically ($p < 0.05–0.001$).

5. Conclusions

1. The positive influence of kettlebell lifting on the functional abilities of the cadets` respiratory system is determined – the indices of vital capacity, timed inspiratory and expiratory capacities, life index of the cadets who were attending a kettlebell lifting class, are better than the indices of the cadets who were studying according to the current system of physical training in the last years of study authentically ($p < 0.05–0.001$).

2. The respiratory system indices are improved with increased sports qualification – kettlebell lifters of the high class (Masters of Sport and Masters of Sports of International Class) have authentically better indices than the cadets of lower qualification ($p < 0.05–0.001$) that confirms the positive effect of kettlebell lifting on the functional abilities of the main systems of the cadets` organisms.

3. The high level of the functional abilities of the cadets` respiratory system will ensure the improvement of the efficiency of the future professional military (combat) activity's tasks performance that defines the necessity of the motivated application of kettlebell lifting during the physical training of the cadets who are the future Ukrainian Armed Forces` officers.

Future researches will be aimed at studying the impact of various components of the training process on the competitive results in kettlebell lifting.

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