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ACUTE DECREASE IN LUNG CAPACITY CAUSED BY INTENSIVE SWIMMING IN STUDENTS

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Abstract

The main goal of this research was to examine the decrease in lung capacity influenced by load caused by swimming, that is, to what extent the fatigue affects the change in lung capacity and to what extent the maximal inhalation and exhalation after the 200m crawl technique section is decreased. Inadequate breathing (inadequate exchange of oxygen and carbon dioxide) causes fatigue more quickly. Breathing in water, due to hydrostatic pressure, is harder than breathing ashore. Therefore, it is harder to keep the swimmer's body position in water. It is harder to overcome the forces which interfere the swimming, the coordination is being obstructed as well as the swimming technique. All that weakens the result, therefore the attention should be on the education of breathing technique during swimming specifically. Accordingly, the goal of this research has been set – "to determine the decrease in lung capacity influenced by load caused by swimming." If the decrease of lung capacity is proven, the significance of training in swimming technique is affirmed. Students of the second year at Faculty of Sports and Physical Education of University of Sarajevo were involved for the research – 26 male students. During the research, four measures of the lung capacity were done, which showed that load caused by swimming influences the lung capacity negatively.

T-test did not show any statistically significant difference ($p=0.558$) for the maximal expiratory pressure for the first second of measurement at standing in water and lying in water ($p=0.225$). The indicator in the sixth second, at standing in water, showed significant difference a ($p=0.038$, $\eta^2=0.16$). At lying position, in the sixth second, the difference which was also significant ($p=0.006$, $\eta^2=0.27$). Significant correlation of air flow in the first measurement – standing in water ($p=0.023$, $\eta^2=0.17$) and second measurement – lying in water ($p=0.050$, $\eta^2=0.14$) was noted.

In conclusion it can be argued that the load caused after the 200m crawl technique section affects the lung capacity negatively and obstructs the breathing. As a recommendation for further work with students, but also for other swimmers of similar characteristics, it is necessary to dedicate more lessons to the practice of breathing technique.

Key words: **Hydrostatic pressure, Fatigue, Inspirium, Expirium**

Introduction

Breathing in water is significantly different than breathing ashore, due to the load caused by hydrostatic pressure. Furthermore, breathing in water is affected by specific body position – it depends on the swimming technique, but also on water which can interfere with the respiratory organs by sprinkling. Inadequate breathing obstructs the swimming and poses a threat of carbon dioxide accumulation (disorientation, suffocation of the swimmer). Water, by its pressure, prevents the air volume from ejection from the lungs with maximal exhalation, after the maximal inhalation which represents the vital capacity (Hadžović – Džuvo, A. & Kapur, E. 2011). Therefore, the breathing technique training while being in water should be especially considered. Inaccurate breathing also causes accelerated fatigue which disturbs the hydrodynamic body position maintenance. The fatigue further affects the decrease of time spent in water and time dedicated to the training of swimming technique. A negative, closed circle then is formed, because: the breathing technique is disturbed, oxygen flow into the organism is decreased, fatigue is accelerated, the swimming technique is disturbed, the effort is increased in order to maintain the accurate body position and the time length in water is reduced. Regardless of the fact that, during swimming, the swimmers hold the horizontal body position and reduce the load on the respiratory organs – the postural role of the thorax and abdominal muscles is smaller, as well as the tightening role of the diaphragm (Druz, W. & Sharp, J. 1981), breathing in water is not easier. This claim is proved by the increased water pressure around the chest, which pushes the walls of thorax towards inside when the respiratory organs are relaxed (Withers, R. & Hamdorf, P. 1989, Frangolias, D. & Rhodes, E. 1995). The diaphragm cannot function on the mechanically efficient level then (Henke, K., Sharratt, M., Pegelow, D. & Dempsey, J. 1988). Physiological load on the heart and blood vessels is increased due to the horizontal body position. Due to the external pressure caused by immersion the blood moves from the lower extremities to the chest (Ray AD, Pendergast DR & Lundgren CE. 2008, Frangolias, D. & Rhodes, E. 1996) so the blood flow to the heart and lungs is increased, that is, besides the fatigue of muscles upon the swimming activity there is this additional aggravating circumstance while breathing. Breathing at crawl technique can be considered quite complex regarding the head being immersed in water face down and the inhalation being done by turning the head left and right. To overcome the oxygen shortage, but also maintain endurance in swimming, and for the swimmer to stay in the aerobic phase of work as long as possible, the air intake (Maglischo E.W. 2008) must be perfectly balanced with the arms technique. Air is inhaled when the arm in its movement through the air is finishing the retropulsion phase, immediately before the fist comes in the water, that is, the other arm is in the transition phase for a new stroke. The exhalation is completely done through the nose and mouth while the swimmer's face is immersed in water. Due to all the aggravating factors of breathing in water, the body changes the process and adjusts so that, during swimming, the frequency of breathing is lower and respiratory volume is higher in comparison with spontaneous breathing (Dicker, S., Loftus, G., Thornton, N. & Brooks, G. 1980, Rodriguez, F.A. 2000). Therefore, while swimming the crawl technique, the water environment causes accelerated muscles fatigue and reduction of oxygen intake in the organism, so mastering the breathing technique would be significant. The main goal of the research is to examine the decrease in lung capacity influenced by swimming load, that is, to what extent the fatigue affects the change in lung capacity (Maglischo E.W. 2008, Holmer, I. & Gullstrand, L. 1980, Hsieh, S. & Hermiston, R. 1983, Lerda R., Cardelli C., Chollet D. 2001, Pedersen T., Kjendlie P.L. 2003) and to what extent the maximal inhalation and exhalation after the 200m crawl technique section is decreased.

Methods

Participants

Participants' sample involved the male students at Faculty of Sports and Physical Education of University of Sarajevo. The students' age ranged from 20 to 22 years, their average height was mean±SD: 1.73±0.08m, while the weight ranged from 70.5±10.8 kg. The research included 26 male students. None of the participants had any history of cardiorespiratory diseases, they were all non-smokers, and the research procedure was done in the regular classes of the Swimming course. All the participants had the same optimal conditions for regular attendance and passed the Swimming course, which ensured that they can apply the appropriate quality of crawl technique swimming. The written consent forms to voluntary participation in the research from all the participants have been collected. Positive approval from the ethics committee on the testing execution was obtained beforehand.

Measurement conditions

Testing was done in the Olympic pool in Sarajevo at the transversal length of 25m. The students had to swim 200m with crawl technique, more precisely to swim eight times the given length. The water temperature was +27C °, humidity of the facility was 58,70%, air temperature +29,64 C ° and chlorine level 0,5 mg/L, which was within acceptable limits. The participants were informed on the protocol of the research and the way of measurement before the testing. The first step was to introduce the participants to the measurement of maximal inspirium and expirium in the upright position, and in the horizontal position subsequently. The measurement was done in the pool while the body was immersed in water. They were also informed that the measurement will be repeated after the 200m crawl technique section with maximal swimming speed. The maximal exhalation, in the horizontal position was particularly interesting, since it brings closer the knowledge of breathing which is similar to the body position when swimming the crawl technique. During the procedure, participants were prepared for 10 minutes before the testing and entering the water, which was followed by the respiratory muscles warm up. The latter was performed by 200m crawl technique swimming with speed which corresponds the +/-80% tempo of the control test. Such procedure was done in order to introduce the muscles to the complete testing gradually.

Maximal *inspirium* and *expirium* measurement procedure

The maximal inspiratory pressure was measured on the mouth with the means of a portable manual device (Micro Medical Ltd, Kent, UK) which measures the air flow in the first and sixth second of exhalation. The previous researches have shown that the respiratory muscles warm up before the testing is very important (Volianitis, S., McConnell, A.K., Koutedakis, T., McNaugh- ton, L., Backx, K. and Jones, D. 2001) so the example was followed in this research accordingly. In the experimental trials it was noticed that the warm up has a major role and shows more objective results of testing. Commercially available trainer of respiratory muscles (POWERbreathe®, Leisure Systems International Ltd, UK) was used for inspiratory warm up, which was performed while using the methods described (Volianitis, S., McConnell, A.K., Koutedakis, T., McNaugh- ton, L., Backx, K. and Jones, D. 2001). On every occasion, the participants did the maximal inspirium and expirium while they were standing upright next to the pool or lying down in the pool (face up). When the participants were in the lying position their legs were leaned on the fixed mobile stall, so that the body movement would be reduced. Although the front crawl swimming requires stretched body position with "face in the water", due to the applied devices it was not possible to measure the maximal inspiratory pressure in the stretched immerged position. There were three measurements each before the 200m crawl technique swimming, in the upright and lying position (the best results were recorded), whereas, after the swum section, the expirium was measured only once in the upright and then only once in the lying position. Such procedure was performed due to the load that the participant had endured. The results from all the participants were taken into the final processing and data interpretation afterwards (Hill, N., Jacoby, C. and Faber, H. 1991).

Statistical analysis

The obtained data were processed in the SPSS 22.0 program package for Windows. For determining significances in differences between the first and the second measurement, T-test for dependent samples was applied. When significance was observed partial ETA squared (η^2) was calculated. Indications of η^2 values were classified as: 0.01 - small influence, 0.06 - middle influence and 0.14 - great influence. Statistical significance was set at 99%.

Results

When it comes to individual observance of variables, it can be noted that T-test did not show any statistically significant difference ($p=0.558$) for the maximal expiratory pressure for the first second of measurement at standing in water. The same statement can be indicated for the maximal expiratory pressure in the first second of measurement at lying in water ($p=0.225$). As regards to the indicator in the sixth second, at standing in water, significance was noted ($p=0.038$, $\eta^2=0.16$). At lying position, in the sixth second, similar result was observed ($p=0.006$, $\eta^2=0.27$). At both positions in water, both variables which show the air flow from the 1st to the 6th second indicate defined statistical significance. Significant difference of air flow in the first measurement – standing in water ($p=0.023$, $\eta^2=0.17$), and second measurement – lying in water, ($p=0.050$, $\eta^2=0.14$) was noted. According to the results it can be claimed that the measured expirium, after 200m crawl technique swimming, was affected by fatigue caused by maximal effort.

Table 1 The Difference's in Lung Capacity Before and After Swimming

Measurements	Mean	SD	SEM	95% CI Lower/ Upper	t	df	p	η^2
SPIR1S	-0.071	0.590	0.120	-0.321/0.177	-0.594	23	0.558	
SPIR1L	0151	0.595	0.121	-0.099/0.403	1.247	23	0.25	
SPIR6S	0.431	0.963	0.196	0.024/0.838	2.195	23	0.038*	0.16
SPIR6L	0.173	0.278	0.056	0.055/0.291	3.045	23	0.006**	0.27
FLOWS	-0.068	0.146	0.029	-0.130/-0.006	-2.283	23	0.032*	0.017
FLOWL	-0.058	0.138	0.028	-0.116/0.000	-2.067	23	0.050*	0.14

*** p<0.01; *p<0.05; SD- standard deviation; SEM – standard error of mean; 95% CI – 95% confidence intervals; df- degrees of freedom; η^2 – partial eta squared; SPIR 1S-The Difference's in Lung Capacity Before and After Swimming the First Second-Measured by Standing; SPIR 1L -The Difference's in Lung Capacity Before and After Swimming the First Second-Measured by Lying; SPIR6S -The Difference's in Lung Capacity Before and After Swimming the Six Second-Measured by Standing; SPIR6L- The Difference's in Lung Capacity Before and After Swimming the Six Second-Measured by Lying; FLOW1S- Average Airflow-Measured by Standing; FLOW2L- Average Airflow-Measured by Lying*

Discussion

After all the needed data was completely collected, it can be stated that all the participants performed the test accordingly and they were well informed on the testing technique. As for analysis of the given results it can be observed that at the maximal expirium in the first second, between the initial and final measurement of exhalation, statistically significant difference was not registered. Measurement was done in two positions, standing in water and then lying in water. It can be presumed that measuring time was too short to register any difference in exhalation capacity. It is evident that the fatigue caused by predicted load could not affect the occurrence of expected difference. Differences in exhalation capacity can be confirmed only in the sixth second. Differences are evident, and they appeared in both positions in which the testing was done in the sixth second, both at standing in water and lying in water. As for lying position, differences in expirium are more evident (Volianitis, S., McConnell, A.K., Koutedakis, T., McNaugh- ton, L., Backx, K. and Jones, D. 2001). 200m crawl technique swimming with maximal effort proved to be appropriate load for respiratory musculature of student population. However, that there is not big difference between these two measurements, which is opposite of expectation, is proved by the calculated ETA coefficient. For the variables of air flow from the 1st to the 6th second the statistical significance of difference was determined both at standing and lying in water. Therefore, here as well the effort caused by maximal speed of 200m crawl technique swimming had certain influence, that is, it caused fatigue and negative influence on the lung capacity. Unfortunately, the η^2 coefficients have low values here too. If these indicators are to be compared to the indicators for the top swimmers (Volianitis, S., McConnell, A.K., Koutedakis, T., McNaugh- ton, L., Backx, K. and Jones, D. 2001) and (Lemaitre F., JB., Coquart, F., Chavallard, I., Castres, P., Mucci, G., Costalat and D., Chollet 2013), who have swum at the length of 50m and 200m, we will notice that the expansion of thorax – by strength of respiratory muscles, was improved by training, namely they can resist the fatigue for longer, without reducing their lung capacity. Here, of course it can be assumed that the "inner breathing" has improved too, the gas exchange in the lungs respectively. This segment however is not a subject of this research. On the occasion of crawl technique swimming the swimmers can use various breathing techniques – successive (gradual ejection of the air from lungs into the water) and explosive technique (exhalation in the form of an explosion – into the water as well) and postpone or "overcome" the effects of fatigue by doing so (Maglischo E.W. 2003). Both ways of air ejection are in fact harder than the "normal process of breathing" due to the water density. Therefore, effort is also necessary upon exhalation, which creates even bigger fatigue of the complete system in charge of breathing. More inhalations can give the swimmer some advantages when swimming at length (Lerda R., Cardelli C., Chollet D. 2001) and bring to the fatigue postponement respectively (Pedersen T., Kjendlie P.L. 2003). Hence it is necessary for every swimmer to master the technique as well as the tactic of breathing (Maglischo E.W. 2003). The reason for this recommendation is the knowledge from this research in which the exhalation volume reduction in the sixth second and air flow reduction from the 1st to the 6th second after swimming the 200m section are evident. With this, the research goal was achieved, and it was proven that "the load caused by the 200m crawl technique swimming section negatively affects the lung capacity" and obstructs the breathing. Along with the training and exercising the breathing muscles strength, the fatigue of respiratory muscles will be postponed (Volianitis, S., McConnell, A.K., Koutedakis, T., McNaugh- ton, L., Backx, K. and Jones, D. (2001), Romer, L.M., McConnell, A.K. and Jones, A. (2002) and the overall performance of the swimmer will be enhanced. The fatigue of respiratory muscles has a major role in limiting the scope and intensity of sports (Johnson BD., Aaron EA.,Babcock MA.,Dempsey JA. 1996) but also teaching activities. Alternatively, a research could be done on a bigger sample and possibly more precise data obtained on what exactly affects the breathing process negatively. Whether it is the breathing technique or only the fatigue of breathing musculature in question.

Conclusion

It has been confirmed that water environment as well as the effort in water – swimming, cause the fatigue of respiratory muscles and the breathing organs functionality deprivation. In order to postpone the fatigue during swimming, trainers as well as the teaching staff who teaches swimming are recommended an intensified work on mastering the technique and tactic of breathing better. It would be interesting to conduct a research on the female student population, as well as the population of athletes in training process of swimming and to compare the given data with the established parameters hereby.

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