INFLUENCE OF OXYGEN CONCENTRATE INHALATION ON PERFORMANCE IN SWIMMING UNDERWATER

Martin Pupiš[1], Zuzana Pupišová[1] and Ratko Pavlović[2]

[1]Department of Physical Education and Sports, Faculty of Arts, Matej Bel University, Slovak Republic
[2]Faculty Physical Education and Sport, University of East Sarajevo, Bosnia and Herzegovina

Original scientific paper

Abstract
The aim of the present study was to analyze the influence of oxygen concentrate inhalation on underwater swimming performance in students from the Department of Physical Education and Sports in BanskáBystrica. The test group consisted of 17 students (9 males: age = 21.14± 1.78 years, height= 176.4± 6.3 cm, weight= 66.2 ± 8.7 kg, and 8 women: age = 20.98± 1.54 years, height= 169.2± 4.2 cm, weight= 60.6± 4.5 kg). The test group carried out the testing over two consecutive days, where their task was to inhale oxygen concentrate/placebo for 2 minutes after a 5-minute collective warm-up and 500 meters of swimming. Subsequently, the role of the test group was to swim the maximum distance underwater with one inspiration and simultaneously push off the edge of the pool. Paired-Samples T-test (t, α = 0.05) was used to establish the significance of differences between the distance of underwater swimming after oxygen concentrate inhalation and distance after the application of the placebo. Cohen's coefficient "d" was used for the calculation of effect size. Statistical analysis was realized with software IBM® SPSS® Statistics V19. The test results showed the average individual differences between oxygen and placebo of 6.89% (2.3 meters). Statistical analysis proved that the difference between the distance after oxygen concentrate inhalation and after the application of the placebo was significant ($t_{(16)}$ = -10.101, p < 0.05, d = 2.45 – large effect).

***Key words**: testing, students, underwater swimming, oxygen inhalation*

Introduction

Nowadays we can find relatively many studies dealing with the influence of hypoxia on the body and on sports performance. Authors such as Morris et al., 2000; Harms, 2000; Peltonen, 2001; Wilber, 2004, 2003; Kay et al., 2008; Suchý et al., 2008, Pupiš et al., 2009, 2010, 2012 and others focused on the confirmation of the positive influence of hyperoxia on athletes' bodies. However, we find many authors, for example Yamyji—Shephard (1985); Murphy (1986) or Robbins et al. (1992) who did not record the positive influence of oxygen inhalation on athletes' bodies when it came to mid-term and long-term load and to stretches of short submaximal or maximum load. In spite of several publications on this subject, polemics about the efficiency of oxygen concentrate inhalation on sports performance still remain. Survies Pupiš et al. (2013a), Suchý et al. (2014) proved the positive influence of hypoxia on recuperation in sport. A similar trend was also recorded during repeated anaerobic performances where better times and quicker recuperation on running load 5x200 m was recorded (Pupiš et al., 2013b). In terms of underwater swimming, Hollemann and Hetting (1990) state that it is possible to increase the current oxygen intake by about 10% when inhaling hyperoxic mixtures (90 —100% oxygen concentration). Of course, Nummela et al. states (2002)the one-time or short-term application of oxygen has a temporary influence and tissue oxygen saturation is only a short-term phenomenon. Underwater swimming is a specific load when the swimmer tries to saturate the body with the maximum amount of oxygen before swimming and they try to overcome the greatest possible distance in one inspiration underwater thanks to "frontloading" by oxygen. Oxygen concentrate could thus create a better predisposition for the increased oxygen saturation of the body when swimming underwater. Within the grant tasks VEGA 1/0414/15 and VEGA 1/0788/16 we focused on the analysis of influence of the oxygen concentrate inhalation on the underwater swimming performance in chosen students on the Faculty of Arts, MatejBel University in Banská Bystrica who regularly do sports. Current findings show that oxygen concentrate inhalation is not inconsistent with anti-doping rules. The World Anti-Doping Agency (from 1 January 2009) considers the following procedures and substances as doping, which can be connected with oxygen consumption increase:

- blood doping, including the use of autologous, homologous and heterologous blood or erythrocytes and similar products of any origin
- artificial increase of the consumption, transmission or delivery of oxygen, including modified hemoglobin products, perfluorochemicals and efaproxiral (RSR 13) but not only limited to them (www.antidoping.cz).

Oxygen concentrate supplementation is not on the list of prohibited substances.

On the contrary, xenon and argon belong to prohibited substances (www.antidoping.sk). The aim of the study was to analyze the influence of oxygen concentrate inhalation on the performance in underwater swimming in chosen students of the Department of Physical Education and Sports in Banská Bystrica.

Methods

Subject characteristics

The test group consisted of 17 students from Department mentioned above where (9 males were in average age = 21:14.± 1.78 years, height = 176.4± 6.3 cm, weight = 66.2± 8.7 kg, and 8 women in average age = 20.98± 1.54 years, height = 169.2± 4.2 cm, weight = 60.6± 4.5 kg). We classify the test group among the population group doing sports because each subject performs sports and physical activity at least 7 hrs. a week as they stated.

Measurement organisation

We carried out the testing for two consecutive days. The testing took place on the premises of the swimming pool of the Department of Physical Education and Sports, Faculty of Arts, Matej Bel University in Banská Bystrica. The swimming pool has 25 meters, a width of 12.5 m and depth of 2.10 m at the starts and 1.20 m at turns. The water temperature was 28° C at the time of testing. The study took place from 8:00—10:00 am in the morning. Mentioned time interval is presented by Jančoková (2000) as the first daily performance peak and the study by Vančová et al. (2015b) has shown that the physical performance of university students was through the day´s peak similar (balanced) and their chronotype was also neither (Vančová et al.,2013, Vančová, 2014; more about chronotype: Vančová et al., 2015a).It is also necessary to mention the fact that men and women from this test group did not go through special training focused on these issues before participation in the study and they were not even familiar with the information when the placebo and oxygen were used.

Measurement

The test group carried out the testing in two consecutive days where their task was to inhale the oxygen concentrate/placebo for 2 minutes after a 5-minute collective warm-up and 500 meters of swimming. Subsequently, the role of a test group was to swim the maximum distance underwater with one inspiration and simultaneously bounce off the edge of the pool. The subjects carried out the testing with the placebo on 12 November 2015 and with oxygen concentrate on 13 November 2015. We carried out the oxygen concentrate inhalation or placebo with the New Life Intensity 2x10 l device(which produces oxygen concentrate 90%±3 at the flow rate 10 $l.min^{-1}$ according to the manufacturer)while we followed the instructions of the manufacturer.

Data Analysis

We chose the following descriptive statistics characteristics – for the measurements of central tendency we used the arithmetic mean (x) and for measures of variability standard deviation (SD). We also used the minimal (min) and maximal (max) value of individual's parameters. The Paired-Samples T-test was used to establish the significance of the differences between the distance of underwater swimming after oxygen concentrate inhalation and distance after the application of the placebo. The normality of the distribution of each indicator was determined through the Shapiro-Wilk test. In all statistical analyses, the type I error (alpha) rate was set at 0.05. The effect size of the means of each indicator was determined by Cohen's coefficient d, calculated as follows: $d = |M|/SD$, where M is the mean of differences, and SD is the standard deviation of differences (Yatani, 2014). The coefficient d was interpreted as follows: d = 0.20 – small effect, d = 0.50 – medium effect, d = 0.80 – large effect (Cohen, 1988, Broďáni 2009). The statistical analysis was carried out by IBM® SPSS® Statistics V19 software (Statistical Package for Social Sciences).

Results and discussion

In the presented study we focused on the analysis of influence of the oxygen concentrate which was used for 2 minutes before load. The testing took place in two consecutive days. Results of research are mentioned in Table 1 and the individual results are arranged from the longest distance swum underwater to the shortest one.

Table 1. The testing results of test group

Subject	P	OC	II
1	47.0	52.0	10.64
2	43.0	45.5	5.81
3	43.0	45.0	4.65
4	42.5	45.0	5.88
5	37.0	40.0	8.11
6	35.0	38.5	10.00
7	34.0	36.0	5.88
8	34.0	35.5	4.41
9	34.0	35.0	2.94
10	30.5	33.0	8.20
11	29.5	31.0	5.08
12	27.5	30.0	9.09
13	27.5	29.5	7.27
14	27.0	28.5	5.56
15	26.5	28.5	7.55
16	25.0	27.5	10.00
17	25.0	26.5	6.00
x	**33.41**	**35.71**	**6.89**
SD	**6.82**	**7.35**	**2.14**
Min	**25.0**	**26.5**	**2.94**
Max	**47.0**	**52.0**	**10.64**

Legend**:** *x—average value; SD—standard deviation; min—max value; max—maximum value; OC (oxygen concentrate)—the test carried out by inhalation of oxygen concentrate content (m); P (placebo)—the test with placebo inhalation (m); II (individual improvement) %*

Table 1. contains data discovered in our study. As we can see, the most significant individual improvement was recorded in Subject 1, whose input was 47 meters and at output measurements the subject was able to swim 52 meters, demonstrating an improvement of 10.64%. The smallest improvement was recorded in Subject 9, who swam 34 meters underwater at input measurements and 35 meters at output measuring, representing an improvement of 1 meter and therefore a value of 2.94 % in percentage terms.
In the test group we recorded an average improvement at a level of 2.3 meters and average individual percentage improvement at a level of 6.89%. The value of the standard deviation was 6.82 at the input measurements and 7.35 at the output measurements. The minimum value of the distance swum was at the level of 25.0 meters at input measurement and at the level of 26.5 meters at the output measurement. The maximum value of the distance swum was at the level of 47.0 meters at the input measurement and at the level of 52.0 meters at the output measurement. We can state that after oxygen concentrate inhalation, there was a positive increase in the distance swum in all subjects and the results confirm the allegations of Hollemann, and Hettinger (1990) according to which the oxygen intake can be increased by about 10% (as we recorded an improvement from 2.94 to 10.64 %). The low number of subjects is the limit of the study (men n= 9 and women n= 8) because it would be necessary to carry out the testing on the higher number of subjects in order to confirm and to generalize the results.

Paired-Samples T-test (t, α = 0.05) was used to establish the significance of differences between the distance of underwater swimming after the oxygen concentrate inhalation and distance after the application of the placebo. Cohen's coefficient "d" was used for the calculation of effect size. The test results showed the average individual differences between the oxygen concentrate and a placebo of 6.89 % (2.3 meters). The statistical analysis proved that the difference between distance after oxygen concentrate inhalation and after the application of placebo was significant ($t_{(16)}$ = -10.101, $p < 0.05$, d = 2.45 – large effect).

Conclusion

The influence of the oxygen concentrate inhalation was confirmed by several studies, to which we can assign our study with the statement of our results. The aim of the our study was to analyse the influence of oxygen concentrate inhalation in comparison to placebo inhalation on underwater swimming performance in students of the Department of Physical Education and Sports in Banská Bystrica. 9 men and 8 women participated in our study, who have been studying physical education and coaching in various kinds of sports.
After the testing of the distance swum underwater after the 2-minute oxygen concentrate inhalation, we reached findings that the performance increased on average 2.3 meters and the average individual improvement of 6.89%. Minimum individual improvement was observed at the level of 2.94% and maximum at the level of 10.64%.

REFERENCES

Broďáni, J. (2009). Využitie mnohonásobnej korelačnej a regresnej analýzy časových radov vo vrcholovom športe. *Forum Statisticum Slovakum*. 5 (1), 6-9.

Cohen, J. (1988). Statistical power analysis for the behavioral sciences (2). New York: Academic Press.

Harms, C., Mcclaran, S., Nickele, G., Pegelow, D., Nelson, W., & Dempsey, J. (2000). Effect of exercise-induced arterial O2 desaturation on VO2max in women. *Medicine and Science in Sports and Exrecise.,32*, 1101-1108.

Hollmann W., Hettinger T. (1990). Sportmedizin. Arbeits- und Trainingsgrundlagen. Stuttgart: Schattauer Verlag

Jančoková, Ľ. (2000). Biorytmy v športe (S úvodom do chronobiológie). Banská Bystrica: FHV UMB.

Kay, B., Stannard, S.R., & Morton, H. (2008). Hyperoxia during recovery improve speak power during repeated Wingate cycle performance. *Brasil Biomot*., *2*, 92-100.

Morris,D.M., Kearney, J.T., Burke, E.R. (2000). The effects of breathing supplement aloxygen medicine altitude training on cycling performance. *Journal of Science and Medicine in Sport*, 3 (2), 165-175.

Murphy C.L. (1986). Pure oxygen doesn't help athletes' recovery. *Physic. Sportsmed*. 14:28-31

Nummela A., Hamalainen I., Rusko H. (2002). Effect of hyperoxia on metabolic response and recovery in intermittent exercise. *Scand. J. Med. Sci. Sports*. 12:309-315.

Peltonen, J., Tikkanen, H., & Rusko, H. (2001). Cardio respiratory responses to exercise in acute hypoxia, hyperoxia, and normoxia. *European Journal of Applied Physiology, 85*, 82-88.

Pupiš, M., Štihec, J., & Broďáni, J. (2009). Vplyv inhalácie 99,5 % kyslíka na organizmus basketbalistov pri anaeróbnom zaťažení. *Exercitatio corpolis - motus –salus. Slovak journal of sports sciences : slovenskýčasopis o vedách a športe. 1 (2),73-78.*

Pupiš, M., Raković, A., Savanović, V., Stanković, S., Kocić, M., & Berić, D. (2010). Hyperoxy as a form of anaerobic workload reduction on the elite bakteball players, *Acta Kinesiologica*, *4 (1),* 45-48.

Pupiš M., Sližik M.& Bartík P. (2013a). The use of hyperoxia as a way to accelerate recovery after a karate and judo match *Journal of Human Sport and Exercise,* 8 (3), 608-614

Pupiš M., Čillík I., Pivovarniček P.& Pavlović R,& Bonacin D. (2013b). The impact of hyperoxygenation on performance and recovery during repeated 200M running load of submaximal intensity *Acta kinesiologica.* 7 (1), 90-95

Robbins, M.K., Gleeson, K., & Zwillich, C.W. (1992). Effects of oxygen breathing following submaxima and maxima exercise on recovery and performance. *Medicine and Science in Sports and Exercise*, 24(6), 720-725.

Suchý, J., Heller, J., Vodička, P. - Pecha, J. (2008). Vliv inhalace 99,5% kyslíku na opakovaný krátkodobý výkon maximální intenzity.*Česká kinantropologie.* 12 (2), 15-25.

Suchý, J., Pupiš, M., Brunerová, L. (2014). Effect of short-term hyperoxia on model exercise in basketball, *GazzettaMedicaItalianaArchivio per le Scieze Medicine,* 173(7-8), 409-416.

Vančová, D. (2014). Chronotypes of university´s students of Matej Bel University. In Rozim, R., Šmída, L., & Bendíková, E. (Eds.). *Študentská vedecká aktivita 2014 : vedy o športe* (pp. 109-116). Banská Bystrica: Belianum.

Vančová, D., Jančoková, Ľ., Palovičová, J., & Pivovarniček, P. (2013). Identification of chronotypes of university students. *Studia sportiva*, *7*(2), 79-84.

Vančová, D., Jančoková, Ľ., & Pivovarniček, P. (2015a). Chronotype as an indicator of personal characteristics and features. *Sport Science*, *8*(1), 94-98.

Vančová, D., Pivovarniček, P., Miňová, J., Bunc, V. & Jančoková, Ľ. (2015b).Evaluation´s options of diurnal variation of physical performance of university students: a pilot study. *Journal of Physical Education and Sport. 15*(3),598-602.

Wilber, R.L. (2003). Effect of F1O2 on physiological responses and cycling performance at moderate altitude. *Medicine and Science in Sports and Exercise.35*(7), 1153-1159.

Wilber, R.L. (2004). Effectof FIO2 on oxidative stress during interval training at moderate altitude. *Medicine and Science in Sports and Exercise*.*36*(11), 1888-1894

Yamaji, K., & Shephard, R.J. (1985). Effect of physical working capacity of breathing 100 percent O2 during rest or exercise. *Journal of Sports Medicine and Physical Fitness*, 25(4), 238-242.

Yatani,K.(2014).Koji Yatani's Course Webpage. [online],http://yatani.jp/teaching/doku.php?id=hcistats:ttest

UTJECAJ UDISANJA KONCENTRATA KISIKA NA IZVEDBU PODVODNOG PLIVANJA

Sažetak

Cilj ovog istraživanja bio je analizirati utjecaj koncentrata inhalacije kisika pri izvedbi podvodnog plivanja u studenata s Odjela za fizičku kulturu i šport u Banskoj Bystrici. Test skupina sastojala se od 17 studenata (9 muškaraca: dob = 21,14 ± 1,78 godina, visina = 176,4 ± 6,3 cm, masa = 66,2 ± 8,7 kg i 8 žena: dob = 20,98 ± 1,54 godina, visina = 169,2 ± 4,2 cm, težina = 60,6 ± 4,5 kg). U ispitnoj skupini provedeno je testiranje tijekom dva uzastopna dana, pri čemu je njihov zadatak bio udisati koncentrat kisika / placebo tijekom 2 minute nakon 5 minuta kolektivnog zagrijavanja i 500 metara plivanja. Nakon toga, uloga ispitivane skupine bila je da pliva maksimalnu udaljenost podvodno s jednom inspiracijom i da se istovremeno odgurne s ruba bazena. Parni uzorci T-testa (t, α = 0,05) su korišteni za uspostavljanje značajnosti razlika između udaljenosti podvodnog plivanja nakon inhalacije koncentrata kisika i udaljenosti nakon primjene placeba. Cohenov koeficijent "d" je korišten za izračun veličine učinka. Statistička analiza je realizirana uz softver IBM ® SPSS® statistiku V19. Rezultati testa su pokazali da su prosječne individualne razlike između kisika i placebo od 6.89% (2,3 metara). Statistička analiza pokazala da je razlika između udaljenosti nakon udisanja koncentrata kisika i nakon primjene placeba bio značajan (t (16) = -10,101, p <0,05, d = 2,45 - veliki učinak).

Ključne riječi: ispitivanje, studenti, podvodno plivanje, inhalacija kisika

Received: November 12, 2015
Accepted: April 15, 2016
Correspondence to:
PaedDr. Zuzana Pupišová, PhD.
Matej Bel University, Faculty of Arts
Department of Physical Education and Sports
974 01 Banská Bystrica, Tajovského 40, Slovakia
Phone: 00421 911414262,
E-mail: zuzana.pupisova@umb.sk