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Preliminary data on low peripheral blood oxygen levels induced by physical effort

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Abstract

Introduction: Since strength and endurance training has become very popular, we aimed to assess the possibility of hypoxemia determined in peripheral blood during exercise, starting from the hypothesis that a relatively large muscle mass would have a protective effect. *Aim:* Hypoxemia can cause serious illness and therefore we consider it useful to investigate the occurrence of this phenomenon during exercises of strength or endurance. *Methods:* The preliminary study was conducted on 8 subjects, both trained and untrained. With a Beurer pulse oximeter, heart rate and oxygen saturation of the capillary blood were measured before, during, and at the end of strength, or endurance or endurance combined with strength training. *Results*: The results have shown that hypoxemia occurs only under the conditions of high intensity training, which alternates endurance with strength exercises, simultaneously with decreasing heart rate, only in trained subjects and with relatively low muscle mass. *Conclusions*: The decrease in oxygen saturation in the peripheral blood occurs simultaneously with that of heart rate and it seems that large muscle mass has a protective effect on oxygen desaturation.

***Key words**: oxygenation, sports activities, muscle mass*

Rezumat

Introducere: Deoarece antrenamentele de forță și anduranță au devenit foarte populare, ne-am propus aprecierea posibilității desaturării în oxigen a sângelui periferic în timpul efortului, plecând de la ipoteza că o masă musculară relativ mare ar avea un efect protectiv. *Scop*: Având in vedere că desaturarea în oxigen poate provoca afecțiuni grave, considerăm utilă investigarea apariției acestui fenomen în cursul exercițiilor de forță sau a celor de anduranță. *Metode*: Studiul preliminar a fost efectuat pe 8 subiecți, atât antrenați cât și neantrenați. Cu un pulsoximetru Beurer s-au măsurat frecvența cardiacă și saturația în oxigen a sângelui capilar, înaintea, în timpul și la sfârșitul unor ședinte de antrenament de forță, de anduranță sau anduranță combinată cu forță. *Rezultate*: Rezultatele au arătat că desaturarea în oxigen a sângelui periferic nu are loc decât în condițiile antrenamentelor de intensitate mare, ce alternează anduranța cu exercițiile de forță, simultan cu scăderea frecvenței cardiace, doar la subiecți antrenați și cu masă musculară relativ mică. *Concluzii*: Scăderea saturației în oxigen în sângele periferic are loc simultan cu frecvența cardiacă și se pare că masa musculară mare are un efect protectiv asupra desaturării în oxigen.

***Cuvinte cheie**: oxigenare, activități sportive, masă musculară*

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Introduction

Research has shown that some healthy individuals undergoing walk tests exhibit a 4% decrease in peripheral blood oxygen levels, unrelated to age, gender, distance traveled or heart rate, but proportional to the body mass index [1]. Several studies [1] concluded that the use of hypoxemia levels for predicting respiratory anomalies may be erroneous.

Unlike untrained and moderately trained subjects, heavy trained endurance athletes may experience exercise-induced arterial hypoxemia [2], which is why future research is needed [3]. The way that ventilation/perfusion rate undergoes changes in distribution during intense exercise is not known [4].

Hypothesis

Since nitric oxide is synthesized in muscle fibers [5] and produces vasodilatation [6], we assume that one of the variables on which oxygen saturation levels depends during exercise is the degree of development of muscle mass.

Aim

Considering the popularity of practicing strength and endurance training (especially aerobics) by people of all ages and with different levels of training, we have proposed a preliminary study to assess whether hypoxemia occurs during these programs, and elucidating some of the factors that depend on it. Since low blood oxygen levels during intense physical activity may cause repeated episodes of hypoxic pulmonary vascular constriction and pulmonary hypertension [1], we consider the study to be important for the safety of leisure sports.

Methods

The research was conducted at the "New Power Gym" Sports Club in Iasi, in July 2017. With a Beurer pulse oximeter, heart rate (HR) and oxygen saturation of capillary blood (SpO_2) were measured in 8 subjects before, during, and at the end of an endurance training session, force session and both endurance combined with force. The programs were individualized and conducted under the supervision of coaches. The gender, age, anthropometric data, and training rate are included in Table 1. The intensity of the effort was consistent with the physical condition of each subject.

One of the authors (Hagiu Bogdan Alexandru) established the working protocol based on evidence in the literature and carried out the measurements. The other two have developed individualized strength-endurance programs.

Table I. Gender, age and anthropometric data of subjects participating in the study

Subject	Gender	Age (years)	Height (cm)	Weight (kg)	Level of trainig
1	F	18	170	76	trained
2	F	28	165	52	trained
3	M	44	178	86	trained
4	M	47	178	86	moderately trained
5	F	22	170	63	untrained
6	F	51	169	59	untrained
7	F	42	168	55	trained
8	F	35	160	55	trained

Results

The results are included in Tables 2-9. The following tables contain the initial values of SpO_2 and HR (considered as those recorded before the start of the training program, or, by case, at the end of the warm-up) and the data measured during the breaks and at the end of training.

Table II. Peripheral oxygen saturation levels and heart rate trends in subject 1

Subject 1	Initial SpO_2	Initial HR (beats/minute)	Type of training	Duration (minutes)	Final SpO_2	HR (beats/minute)
	99[1]	98[1]	endurance	5	98	87
			strength	15	99	121
			endurance	15	97	107
	98[2]	108[2]	endurance alternating with strength	15	97	167
			endurance alternating with strength	8	98	137

[1]Values recorded at the beginning of the first training session (endurance, then strength, followed by endurance), after warming up; [2]values registered at the beginning of the second training session (endurance alternating with strength, then again endurance alternating with strength), after warming up.

Table III. Peripheral oxygen saturation levels and heart rate trends in subject 2

Subject 2	Initial SpO_2	Initial HR (beats/minute)	Type of training	Duration (minutes)	Final SpO_2	HR (beats/minute)
	97[1]	90[1]	strength	10	98	130
	99[2]	67[2]	strength	20	97	134
	99[3]	75[3]	endurance	10	97	147
			endurance alternating with strength	15	89	83

[1] Values recorded after about 20 minutes of strength training.
[2]Values recorded after the break, the same training session.
[3]Values recorded at the start of a new training session (endurance alternating with strength).

Table IV. Peripheral oxygen saturation levels and heart rate trends in subject 3

Subject 3	Initial SpO_2	Initial HR (beats/minute)	Type of training	Duration (minutes)	Final SpO_2	HR (beats/minute)
	93[1]	83[1]	endurance	20	97	164
			strength	10	98	133
	96[2]	96[2]	endurance alternating with strength	15	97[3]	140[3]

[1]Values recorded at the beginning of the training session (endurance, then strength).
[2]Values recorded after about 20 minutes of endurance + strength training.
[3]Values recorded at the end of endurance alternating with strength training.

Table V. Peripheral oxygen saturation levels and heart rate trends in subject 4

Subject 4	Initial SiO_2	Initial HR (beats/minute)	Type of training	Duration (minutes)	Final SpO_2	Final HR (beats/minute)
	99[1]	82[1]	endurance (cycloergometer, with intervals)	40	98	111

[1]Values recorded at the beginning of the training session.

Table VI. Peripheral oxygen saturation levels and heart rate trends in subject 5

Subject 5	Initial SpO_2	Initial HR (beats/minute)	Type of training	Duration (minutes)	Final SpO_2	HR (beats/minute)
	99[1]	112[1]	strength	25	98[2]	124[2]
			strength	15	98[3]	89[3]

[1] Values recorded after 10 minutes of endurance.

[2] Values recorded after the first session of strength training.

[3] Values recorded after the second session of strength training.

Table VII. Peripheral oxygen saturation levels and heart rate trends in subject 6

Subject 6	Initial SpO_2	Initial HR (beats/minute)	Type of training	Duration (minutes)	Final SpO_2	HR (beats/minute)
	97[1]	79[1]	endurance (cycloergometer)	25	98[2]	121[2]
			endurance (aerobic)	30	98[3]	112[3]

[1]Values recorded at the beginning of the training session.

2Values recorded after first endurance training – cycloergometer.

3Values recorded after second endurance training – aerobic.

Table VIII. Peripheral oxygen saturation levels and heart rate trends in subject 7

Subject 7	Initial SpO_2	Initial HR (beats/minute)	Type of training	Duration (minutes)	Final SpO_2	HR (beats/minute)
	97[1]	106[1]	endurance	3	99	165
			strength	3	99	131
			endurance	3	99	179
			strength	3	99	137
			endurance	2,5	98	172
			strength	2,5	98	136
			endurance	2,5	**89**	119
			strength	2,5	97	140
			endurance	1,5	98	171
			strength	1,5	98	143
			endurance	1,5	98	166
			strength	1,5	98	114

[1]Values recorded after warming up.

Table IX. Peripheral oxygen saturation levels and heart rate trends in subject 8

Subject 8	Initial SpO_2	Initial HR (beats/minute)	Type of training	Duration (minutes)	Final SpO_2	Final HR (beats/minute)
	99[1]	88[1]	endurance (aerobic)	60	99	144

[1]Values recorded at the beginning of the training session.

Discussions

We observed a SpO_2 drop below 90 occurred in subjects 2 (8% versus baseline) and 7 (10% versus baseline), who underwent high intensity workouts. Subject 2 presented with hypoxemia after 25 minutes of exercise (89% SpO_2 after 15 minutes of endurance/force training versus 97 % SpO_2 after 10 minutes of endurance). They correspond to a decrease of the heart rate (respectively 83, 147, 75 beats/minute). By comparison, even if subject 1 did only 23 minutes of alternative strength training with endurance, no degree of hypoxemia occurred even

after the heart rate started to drop (137 beats/minute and 98 % SpO_2 after 23 minutes from the onset of effort, compared to 167 beats/minute and 97 % SpO_2 after 15 minutes and 108 beats/minute with 98 % SpO_2 at the beginning). In subject 7, desaturation (89 % SpO_2) appeared after about 26 minutes from the onset of training, consisting of endurance/strength, simultaneously with a decrease in heart rate, then returned to the previous values. On the other hand, subject 3 did not suffer from hypoxemia, in spite of the fact that it went for 15 minutes through a similar exercise program with subjects 2 and 7, this after 30 minutes of endurance exercise combined with strength exercises. In subjects 2 and 7 desaturation occurred at a similar time interval with performance cyclists performing endurance exercise [7]. Subjects 2, 3 and 7 are trained and have performed high intensity training programs. The difference in reactivity can be attributed to the greater muscle mass of subject 3. The untrained subject 1, who performed an endurance/strength program, did not present hypoxemia. The cause can be high muscle mass or low effort level. It should be noted that in subject 8, desaturation did not occur after 60 minutes of aerobic training, so the duration of the effort is probably not a determining factor for lowering the partial oxygen pressure in the capillary blood.

Unlike previous studies that have found that hypoxemia occurs more easily in individuals with large body mass index [1], our results suggest that muscle mass has a protective effect. Although we did not establish body composition, the study subjects presented athletic figures. The results are in agreement with the fact that exercise-induced hypoxemia occurs predominantly in endurance athletes [2], which have a relatively small muscle mass than those who do strength training. In consensus with our results is a research that shows that in the elderly aerobic training improves cardiac parameters, but not SpO_2 levels [8]. The explanation is probably the progressive sarcopenia of the elderly, uncompensated during endurance training.

Conclusions

1. Under the conditions of dosed physical effort, performed under the supervision of the coach, it appears that hypoxemia occurs only under the conditions of high intensity training, which alternates the endurance with strength exercises, and only in trained subjects.
2. In this study, the decrease of blood oxygen levels occurs simultaneously with that of heart rate.
3. Preliminary data show that a relatively large muscle mass allows for a program of endurance exercises combined with strength exercises with no influence on blood oxygen levels.

References

1. Seixas D.M., Tsukumo Seixas D.M., Pereira M.C., Moreira M.M., Paschoal I.A. (2013). *Oxygen desaturation in healthy subjects undergoing the incremental shuttle walk test*, J. bras. Pneumol., 39, 4, 440-446.
2. Powers S.K., Dodd S., Lawler J., Landry G., Kirtley M., McKnight T., et al. (1988). *Incidence of exercise induced hypoxemia in elite endurance athletes at sea level,* Eur. J. Appl. Physiol. Occup. Physiol., 58, 3, 298-302.
3. Prefaut C., Durand F., Mucci P., Caillaud C. (2000). *Exercise-induced arterial hypoxaemia in athletes: a review,* Sports Med, 30, 1, 47-61.
4. Dempsey J.A., Wagner P.D. (1999). *Exercise-induced arterial hypoxemia,* J. Appl. Physiol., 87, 1997-2006.
5. Fujii Y., Guo Y., Hussain S.N. (1998). *Regulation of nitric oxide production in response to skeletal muscle activation,* J. Appl. Physiol. , 85, 6, 2330-2336.
6. Dusting G.J. (1996). *Nitric oxide in coronary artery disease: roles in atherosclerosis, myocardial reperfusion and heart failure,* EXS., 76, 33-55.
7. Lain D., Granger W., Boulder C. (2013). *Oxygen saturation and heart rate during exercise performance,* Conference Paper in Anesthesia & Analgesia, october 2013, abstract available from https://www.stahq.org/files/1813/5845/7616/18_Lain2_Abstract.pdf.
8. Sîrbu E. (2012). *The Effects of Moderate Aerobic Training on Cardiorespiratory Parameters in Healthy Elderly Subjects*, Journal of Physical Education and Sport, 12(4), 560-563.