Romanian Reports in Physics, Vol. 66, No. 4, P. 1056–1060, 2014

LASER SPECTROSCOPY APPLIED TO ANALYSIS OF ACTIVE YOUNG WOMEN'S BREATH

C. POPA

National Institute for Laser, Plasma, and Radiation Physics, Department of Lasers,
409 Atomistilor St., PO Box MG-36, 077125 Bucharest, Romania
"Politehnica" University of Bucharest, 313 Splaiul Independentei St., Bucharest, Romania
*Email: cristina.achim@inflpr.ro

Received September 2, 2013

Abstract. The purpose of this study was to investigate the effect of aerobic training on oxidative stress by measuring the ethylene biomarker using the laser photoacoustic spectroscopy (LPAS) method. Three women (30–40 years old), were included in this research. The exercise training protocol was performed in a fitness class (50 minutes session) and consisted of 10 minutes initiation in the exercises, 30 minutes step and great choreographies with music, the last 10 minutes being dedicated to the body relaxation. The determinations suggested that the ethylene biomarker was smaller after the exercise training protocol than before the exercise, which means that this type of aerobic can protect cells from oxidative stress.

Key words: aerobic, laser photoacoustic spectroscopy, oxidative damage, ethylene.

1. INTRODUCTION

The production of oxidative stress is an uninterrupted biological process in membrane cells. Oxidative stress has been defined as an imbalance between oxidants and antioxidants, prompting cell damage and death [1, 2]. Organisms are constantly exposed to exogenous and endogenous reactive oxygen species (ROS) and reactive nitrogen species (RNS) [2]. Exercise is associated with increases in both ATP (Adenosine-5'-triphosphate) requirements and aerobic or anaerobic metabolism, which result in higher levels of ROS and RNS. Thus, when exercise is strenuous, it causes oxidative attack and cell damage, but when it is done in moderation, it increases the release of antioxidant enzymes. The preventive effect of regular exercise is, at least partly, due to oxidative stress-induced adaptation. This response is systemic and includes the enhancement of antioxidant systems and the reduction of oxidative damage due to changes in redox homeostasis [1, 2].

In the following chapters, I will prove the potential of laser spectroscopy for ethylene detection from the breath of active women practicing a new type of aerobic: Kangoo Jumps.

2. MATERIALS AND METHOD

Ethylene biomarker concentrations were analyzed using the LPAS system developed at Optics and Lasers in Life Sciences, Environment and Manufacturing Laboratory, INFLPR, Bucharest Romania. The technique is very sensitive to the detection and monitoring of trace gases at very low concentrations. The CO_2 laser is of special interest, as it ensures high output power in a wavelength region where more than 200 molecular gases of environmental concern for atmospheric, industrial, medical, military, and scientific spheres exhibit strong absorption bands.

Schematically illustrated in Fig. 1, the LPAS is recognized as one of the state-of-the-art in the field of trace gas detection. It is summarized below and described in detail elsewhere [3].

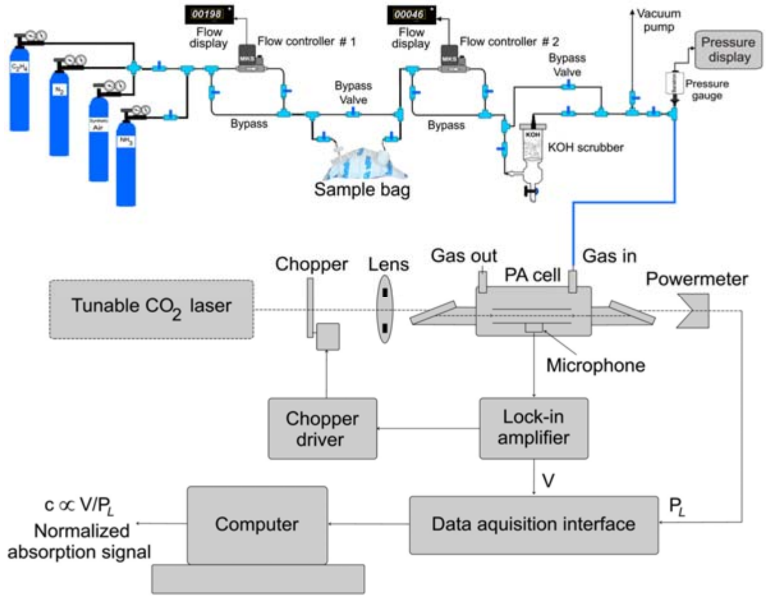

Fig. 1 – CO_2 laser photoacoustic spectroscopy system.

The experimental setup consists of a line-tunable CO_2 laser emitting radiation in the 9.2–10.8 μm region and a photoacoustic (PA) cell, where the gas is detected. The requirement for gases to be detected with this sensitive laser is that they should possess high absorption strength and a characteristic absorption pattern in the wavelength range of the CO_2 laser (*e.g.* 10.53 μm for ethylene).

Inside the PA, traces of ethylene can absorb the laser radiation and the absorbed energy is released into heat, which creates an increase in pressure inside a closed volume. By modulating the laser beam with a mechanical chopper, pressure waves are generated and detected with four sensitive miniature microphones mounted in the cell wall. The electric signal is then fed into a dual-phase, digital lock-in amplifier and its filtered output signal is introduced in the data acquisition interface. All experimental data are processed in real time and stored by a computer [3, 4].

Of great significance in these measurements is the gas handling system due to its role in ensuring gas purity in the PA cell (Figure 1). It can be used to pump out the cell, to introduce the sample gas in the PA cell at a controlled flow rate, and monitor the total and partial pressures of gas mixtures [3].

Women's exhaled breath samples were collected inside aluminized bags (0.75-liter aluminum-coated bags) using a disposable mouth piece connected to the sample bags *via* a homemade Teflon mouthpiece adaptor and after the collection, the sample gas is transferred into the measuring PA cell.

3. RESULTS AND DISCUSSION

We have analyzed exhaled ethylene biomarker from women performing Kangoo Jumps exercises organized at a fitness center in Bucharest. This type of aerobic implies 50 minutes of choregraphies using boots designed to dissipate the impact stress and forces experienced through the ankles, knees, hips and back by up to 80%. Breath samples were collected at certain time intervals (before and immediately after the aerobic program). For this study the volunteers were asked to exhale into sample bags at a normal exhalation flow rate.

The exhaled air sample was transferred to the PA cell at a controlled flow rate of 600 sccm (standard cubic centimeters per minute), and the total pressure of the gas in the PA cell was measured, applying then the correction factor for the responsivity according to the Table 1. The descriptive characteristics of the women W1 to W3 are provided also in Table 1.

Table 1

The particular data of women's and determinations of breath ethylene concentrations

Subjects	**Gender**	**Age**	**p (mbarr) before aerobic**	**p (mbarr) after aerobic**	**R (cmV/W) before aerobic**	**R (cmV/W) after aerobic**	**C_2H_4 (ppm) before aerobic**	**C_2H_4 (ppm) after aerobic**
W_1	Female	34	869	863	340	337	0.051	0.048
W_2	Female	36	894	891	351	350	0.043	0.037
W_3	Female	40	903	891	355	350	0.054	0.048

During the transfer of the exhaled air from the collecting bag to the PA cell, the sample gas was passed through a trap filled with KOH pellets to remove the CO_2 and water [5].

Experimental measurements of breath ethylene concentrations for the volunteere women (three women: W1-W3) participating at Kangoo Jumps training were performed and the results are presented in Figure 2. All women (considered healthy) completed a medical questionnaire to determine the eligibility and no woman was a smoker, alcoholic, diabetic or with chronically affections and didn't took synthetic antioxidants or anti-inflammatory drugs.

The potential volunteers that did not meet the enrolment criteria and did not complete the study were not included in this study.

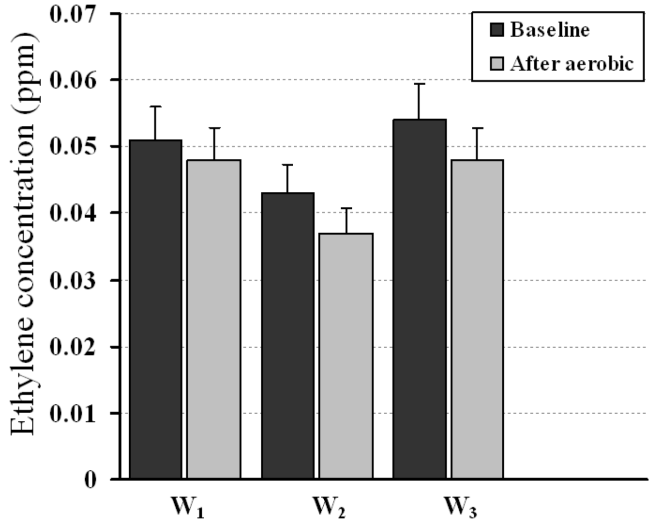

Fig. 2 – Breath ethylene for three women after one exercise session. Baseline determinations are for the initial conditions (before Kangoo Jumps aerobic). The data results for biomarker determination represent ± 10% of two replicates.

In Fig. 2 we measured the by-product of the oxidative stress during aerobic program at three women (with age between 30 and 40 years old) using the exhaled ethylene biomarker as indicator of the oxidative attack. We can observe that the level of ethylene breath biomarker immediately after the aerobic program decreased by 6–14% compared to the biomarker level measured 5 minutes before the start of the Kangoo Jumps exercises. A probable explanation for the decreased ethylene level found after the end of the Kangoo Jumps training might be the role of Kangoo Jumps boots. Due to the reduced impact of exercising with the use of this type of boots, it is also confirmed [6-8] that subjects wearing conventional shoes will have a greater incidence of impact stress than those wearing Kangoo Jumps boots.

The women who practice this type of aerobic (with Kangoo boots) would have a lower incidence of cell damage and increases the expression of antioxidant enzymes.

4. CONCLUSIONS

LPAS is growing quickly in its applications to real world problems - one of the problems is to prevent obesity, being a candidate technology for breath analysis applications. The impact of Kangoo Jumps training on the oxidant system has been investigated. The result of this study showed that there was a lower incidence inside the organism of women immediately post exercise.

More studies would be necessary to assess and evaluate the oxidative attack process involved in the adaptation to Kangoo Jumps boots exercises.

Acknowledgments. Financial support for this study was provided by a Postdoctoral fellowship from the European Social Fund (ESF) through the Operational Programme Human Resources Development (HRD) of University “Politehnica” of Bucharest, April 2014. The time and effort provided by the volunteers is greatly appreciated.

REFERENCES

1. B. Halliwell and JMC Gutteridge, *Free Radicals in Biology and Medicine*, 2nd ed. Clarendon Press, Oxford, 1989.
2. B.M. Escribano, I. Tunez, F. Requena, M.D. Rubio, R. De Miguel, P. Montilla, P. Tovar, E.I. Aguera, Veterinarni Medicina, **55**, 422–428, (2010).
3. D.C. Dumitras D. C. Dutu, C. Matei, A. M. Magureanu, M. Petrus, C. Popa, J. Optoelectron. Adv. Mater., **9**, 3655–3701 (2007).
4. D. C. Dumitras, S. Banita, A.M. Bratu, R. Cernat, D.C.A. Dutu, C. Matei, M. Patachia, M. Petrus, C. Popa, Infrared Phys. Technol., **53**, 308–314 (2010).
5. A. M. Bratu, C. Popa, C. Matei, S. Banita, D. C. A. Dutu, D. C. Dumitras, J. Optoelectron. Adv. Mater., **13**, 1045–1050 (2011).
6. N. Miller, J.E. Taunton, S. Fraser, BSc Rehab, E. Rhodes, B. Zumbo., BCMJ, **45**, 444 (2003).
7. Newton RU., Humphries BJ., Ward IB., *Reducing ground impact forces during jogging: An evaluation of shoes with springs*, Unpublished data, Lismore, NSW, Australia, 1995.
8. Keller TS., Weisberger AM., Ray JL *et al.*, Clin Biomech., **11**, 253 (1996).