Can We Predict Blood Lactate Change Non-invasively during Treadmill Exercise?

Study on Wearable Near Infrared Spectroscopy (NIRS) System

Madoka Yamazaki[1] and Hideo Eda[2]

[1]*Department of Health Science, Daito Bunka University, 560 Iwadono, Higashimatsuyama, Saitama, Japan*

[2]*Department of Medical Photonics, The Graduate School for the Creation of New Photonics Industries, 1955-1 Kurematsu, Nishi-ku, Hamamatsu, Shizuoka 431-1202, Japan*

Keywords: Blood Lactate, Wearable, Nirs, Treadmill, Exercise.

Abstract: Hemoglobin parameters by Wearable Near Infrared Spectroscopy (NIRS) were calculated and compared with the simultaneously recorded blood lactate during treadmill testing. They showed a certain changes associated with the exercise.

1 INTRODUCTION

Blood lactate during exercise has been commonly used to evaluate the training effect and its intensities and to predict the performance endurance in sports laboratories (Bourdon, 2000), (Faude, 2009), (Beneke, 2011). Especially blood lactate threshold and maximal lactate steady state power are highly correlated with the maximum aerobic power and athletic endurance performance. Near Infrared Spectroscopy (NIRS) calculates hemoglobin parameters such as changes in oxygenated hemoglobin (oxyHb) and deoxygenetaed hemoglobin (deoxyHb). It is well known that oxyHb decreases and deoxyHb increases during exersice (Homma, 1996). Now the system has become smaller, and Wearable NIRS has developed (Eda, 2014). Purpose of this study is investigating whether Wearable NIRS can predict the blood lactate change non-invasively.

2 METHODS

Seven track athletes (male / female : 5 / 2, mean age 20yr, height 166.5 cm, weight 58 kg) and non athletes (male / female : 3 / 4, mean age 21.4yr, height 163.3 cm, weight 57.6 kg). All subjects were otherwise healthy and had no history of heart vascular disease and provided written informed consent. The experiment was conducted in accordance with the ethical guidelines of the Declaration of Helsinki, and was reviewed and approved by the Research Ethics Committee of Daito Bunka University (K15-001). Subjects performed treadmill testing (Aeromill, STM-2000, NIHON KOHDEN, Japan) using Bruce protocol. Predicted peak heart rate was calculated as 220 − age. Subjects were encouraged to exercise until 85% of maximum predicted heart rate was achieved. During the exercise and recovery stage, cuff blood pressure, heart rate, cardiac rhythm (Mason-Likar lead system) were recorded. Finger prick blood samples (0.5µl) were taken every 3-5 minutes in the right fingers and measured the blood lactate concentration by using Lactate Pro TM (ArkrayTM, Kyoto, JAPAN). Wearable NIRS was attached the left index finger fixed with medical tape during the exercise. The NIRS calculates haemoglobin parameters We estimated the tissue oxygen level by the Hb parameters.

3 RESULTS

The treadmill exercise duration was from 697 to 1048 (mean 921) seconds in athletes and from 451 to 784 (mean 627) seconds in non- athletes. The athlete's treadmill exercise duration was significantly longer than non-athletes.

Blood lactate concentration increased in association with the intensity of the exercise in all subjects (Figure1 A, B). The changes of the blood

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lactate was from 2.3 to 8.7 (mean 5.1 mmol/l) in the athletes and from 3.0 to 6.1 (mean 4.8 mmol/l) in the non-athletes. There was no significant differences between two groups.

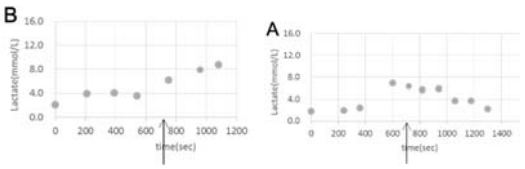

Figure 1: Blood lactate concentration during the exercise. A: case Athlete FS, B: case Non-athlete GT Arrow showed the end time point of the exercise.

Oxy Hb showed a certain changes associated with the exercise. Its pattern was divided into decreasing (4/7 athlete, 3/7 non-athlete : Figure 2A), increasing (2/7 athlete, 3/7 non-athlete : Figure 2B) and no tendency (1/7 athlete ,1/7 non-athlete) pattern.

Deoxy Hb showed no exercise-specific change.

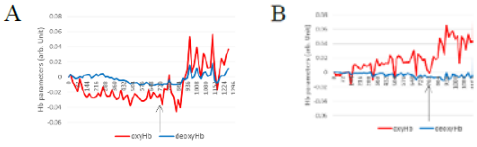

Figure 2: Hb parameters during the exercise A: case Athlete FS. B: case Non-athlete GT. Arrow showed the end time point of the exercise.

4 DISCUSSION

We investigated whether if NIRS can capture the dynamic body signal change which related with blood lactate concentration as the Hb parameters (oxyHb and deoxyHb) during the treadmill exercise. Our Hb parameter results recorded from the fingertip showed no obvious relation between the changing rate of blood lactate concentration and the Hb parameters. Dynamics of the lactate is complicated which not only released but absorbed at the same time and the lactate clearance is different between the individuals (Faude 2009).

There have been several studies which evaluated the Hb parameter changing for the local skeletal muscle by using NIRS (Hamaoka 1992, Homma, 1996, Boushel 1998, Celie 2012). They reported that decreased oxyHb reflected the exercise intensity and metabolic rate. In this study, we may capture the results of dynamical changes which affected the Hb oxidation or deoxydation throughout the body as we attached NIRS module on the finger not on the skeletal muscle related with the treadmill exercise.

Our wearable NIRS has advantages for monitoring the physiological changes sampled from everywhere in the body non-invasively. There has several problems for the feature studies. We need further evaluations whether if the Hb parameters differ in the sampling location and cautions for interpreting the dynamic changing of the Hb parameters. However this wearable NIRS has potential to be an easy use, non-invasive and portable whole body sampling device which can capture the physiological changes.

ACKNOWLEDGEMENTS

This research was supported by Genial Light.co., LTD, Hamamatsu, Japan and ALPS ELECTRIC CO., LTD, Tokyo, Japan

REFERENCES

Bourdon, P. 2000, Blood lactate transition thresholds: concepts and controversies. Physiological tests for elite athletes

Faude O, Kindermann W, Meyer T 2009, Lactate threshold concepts: how valid are they? Sports Med.

Beneke R, Leithäuser RM, Ochentel O. 2011,Blood lactate diagnostics in exercise testing and training. Int J Sports Physiol Perform.

Homma, S., Eda, H., Ogasawara, S., Kagaya, A.,1996 Near-infrared estimation of O2 supply and consumption in forearm muscles working at varying intensity", J. Appl. Physiol..

Eda, H., et al., "Development of wearable monitoring system for acquisition of physiological information from diverse portions of the whole body using near infrared lights (NIRS)", Society for Neuroscience 2014.

Hamaoka, T., Aibani, C., Chance, B., and Iwane, H. 1992, A new method for evaluation of muscle aerobic capacity in relation to physical activity measured by near-infrared spectroscopy. Med. Sport. Sci..

Boushel R, Pott F, Madsen P, Rådegran G, Nowak M, Quistorff B, Secher N.1998, Muscle metabolism from near infrared spectroscopy during rhythmic handgrip in humans. Eur J Appl Physiol Occup Physiol.

Celie B, Boone J, Van Coster R, Bourgois J.2012, Reliability of near infrared spectroscopy (NIRS) for measuring forearm oxygenation during incremental handgrip exercise. Eur J Appl Physiol.