Estimation of cardiopulmonary fitness during daily life

Chiyul Yoon, Joong-Woo Ahn, Eunjeh Hyun, Hee Chan Kim, Hyung-Jin Yoon

Abstract— **Despite the importance of cardiopulmonary fitness, there has been no practical and simple method developed to estimate maximum oxygen uptake (VO2max) without a specific exercise protocol. We developed and tested a VO2max estimation system using heart rate (HR) and activity energy expenditure (aEE) during daily life.**

I. Introduction

Previous numerous studies revealed the reliability and feasibility of conventional accelerometer-based physical activity monitoring. However, physical activity monitors only measure the quantity of movement and do not provide the information on physical fitness that is related to the ability or capacity of physical activity. The purpose of exercise should be increasing both physical activity and fitness, and monitoring physical fitness is as important as physical activity monitoring. Especially, cardiopulmonary fitness which represented by VO2max was focused on.

The estimation methods of VO2max without the use of a specific exercise protocol in daily life using accelerometers with [1] or without [2] continuous heart rate (HR) monitoring were developed. Previous studies need 7 days to measure VO2max, therefore, it was not practical to use.

In this study, we developed a non-intrusive VO2max estimation system for use in daily life by using HR and activity energy expenditure (aEE) in 15 hours. The estimated aEE, HR, and anthropometric value were used to develop a regression model to estimate VO2max.

II. Methods

Eighteen healthy men were voluntarily participated in the study. This study was approved by the IRB and all participants signed written informed consent forms and were provided explanations of the study.

VO2max was measured with a respiration gas analyzer and aerobic exercise test system. To determine the measured value of VO2max, the standard Bruce protocol was used. The participants wore a Shimmer ECG sensor on the chest (Shimmer platform with ECG sensor module, Shimmer, Dublin, Ireland) and the acceleration signal and ECG were captured on the chest for 4 consecutive days. Heart rate and activity energy expenditure (aEE) [3] were calculated in every 1 minute.

A simple linear regression equation was developed using HR and aEE, and maximum aEE (aEEmax) was estimated with the maximal HR determined by age (220-age). The aEEmax and anthropometric value were used to develop a multiple linear regression model to estimate the VO2max, and the correlation between measured and estimated VO2max was analyzed.

Research was funded by NMC (NMC 2013-MS-02) and NRF (BK21 Plus Program and 2005-2001287) in South Korea.

C. Yoon, J. W. Ahn, and E. Hyun are with Interdisciplinary Program of Bioengineering, Seoul National University Graduate School, Seoul, Korea.

H. C. Kim and H. J. Yoon are with the Department of Biomedical Engineering, Medical Research Center, Seoul National University College of Medicine, Seoul, Korea (e-mail: hckim@snu.ac.kr, hjyoon@snu.ac.kr).

(corresponding author to provide phone: 82-2-2072-7516; fax: 82-2-745-7870; e-mail: hjyoon@snu.ac.kr)

III. Results & Discussion

The VO2max was estimated by a multiple regression model using aEEmax and height. The estimated VO2max was strongly correlated to the measured VO2max value ($R=0.88$, adjusted= 0.75, and SEE= 2.51 mL/min/kg, $p<0.001$). The regression formula was expressed as VO2max (mL/min/kg) = 0.103 aEEmax (J/min) - 31.952 height (meter) + 92.532.

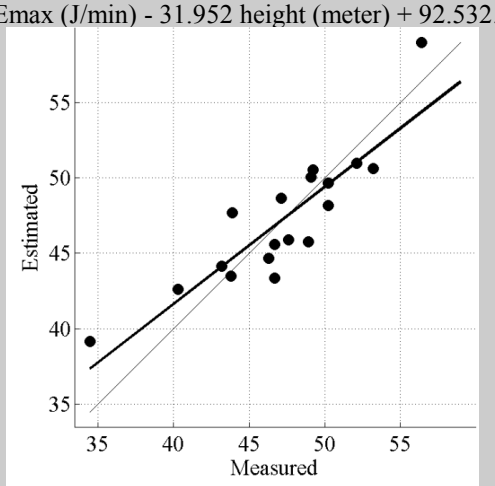

Figure 1 Comparison between measured and estimated VO2max

We improved the previous non-exercise protocol VO2max estimation methods in two aspects. First, our method needs only 15 hours of measurement, which is the shortest period compared with previous studies. Second, the performance of the estimation regression model in this study was comparable to that of previous reports despite the much shorter measurement duration.

However, the number of participants was not large enough, and we could not separate the participants into two groups to establish and validate the regression model. Further study which enlarge participants was planned to overcome our limitation.

54 pt
0.75 in
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References

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