Validity and Usefulness of the Simple Assessment of Lactate Threshold in Younger Adults

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[Received August 8, 2003 ; Accepted December 11, 2003]

The purpose of this investigation was to examine the validity of the exercise intensity of which lactate increased 0.1 mmol/l from baseline level (METs@LAr+0.1), as for the practical assessment of lactate threshold (LT), in younger adults. Thirty-two apparently healthy younger adults (21±1yr., 167.5±10.2cm, 58.2±9.4kg) performed submaximal bench stepping test, in order to determine the LT and METs@LAr+0.1. The LT (8.6±1.1METs) and METs@LAr+0.1 (8.7±1.4METs) were not significantly different, with the strong correlation (r=0.925, p<0.001). The mean error(%), the standard error of estimation (%) and the total error were -0.1±0.6 METs (-0.5±6.7%), 0.44 METs (5.1%) and 0.53 METs, respectively. Furthermore the lower and upper limit of agreement were -1.1 METs (-13.2%) and 1.0 METs(11.6%), respectively. These results suggest that METs@LAr+0.1 can estimate the LT with ±15% of error. Thus the METs@LAr+0.1 may be a valid and useful assessment of LT in younger adults.

Keywords: lactate threshold, step test, graded exercise test

1. Introduction

Aerobic capacity is strongly correlated with the physical functions, and the greater health benefits may be achieved by improvement of aerobic capacity [ACSM, (2000)]. In many advanced countries, since the high prevalence and increase of prevalence at younger adults have been severe problem in addition to the aging, all adults should be encouraged to improve aerobic capacity. Therefore, the health promotion and epidemiological fields have required the simple and accurate assessment of aerobic capacity in order to prescribe the optimal exercise intensity for variety aged populations.

Lactate threshold (LT) is an superior indicator of aerobic capacity as well as maximal oxygen uptake, and the safety and the effectiveness of this intensity have been widely accepted in order to elicit numerous health benefits [Yoshida et al., (1987); Tanaka and Shindo (1992); Tokmakidis et al., (1998)]. Since LT is generally evaluated as the exercise intensity at which blood lactate concentration (LA) increases steeply from the level at rest, assessment has involved technical knowledge and costs for frequent sampling and analysis, thus it is not easy to use LT in the certain clinical fields.

We have developed a simple assessment of LT and have reported on its validity in older people [Ayabe et al., (2003)]. Briefly, our previous report demonstrated that a exercise intensity of which LA increased 0.1 mmol/l above baseline level would be a substitute for LT. By means of this simple assessment, the number of blood sampling is 4-5 times, and the termination criteria of exercise test is 2 mmol/l of LA, thus the cost, efficiency and safety of LT assessment will be dramatically improved. Furthermore, in recent years, accompanying the development of portable and easy-to-use analyzer [Pyne et al., (2000)], LA can be measured accurately and quickly in the health promotion fields by a very small blood sample.

The purpose of this investigation was to examine the validity of METs@LAr+0.1 in younger adults,
as the basic research to develop a practical graded exercise test for variety aged and conditioned individuals.

2. Methods

2.1. Subjects

The subjects of this research were 32 healthy university students, 16 men and 16 women. Age, height, weight, body fat as measured by the underwater weighting method and peak oxygen uptake as measured by a bicycle ergometer, are shown in Table 1.

After explanation of the study design and requirements, all participants signed a consent form.

2.2. Graded exercise test

The graded exercise test used a submaximal graded step test, following the our previous investigation [Ayabe et al., (2003)]. Exercise intensity was decided according to the exercise habits and aerobic capacity individually. The platform height was 20 or 25 cm, and the stepping rate was from 15 to 40 ascends/minute. The METs value estimated by the bench height and the stepping frequency was 4-7 METs at a first stage, and was increased 0.97 METs every stage [ACSM (2000)]. Exercise duration was 4 minutes per stage, and a 2-minute rest period was set between stages. In order to determined LA, 5 μl of blood was sampled from the earlobe at rest period and following each stage, using a portable blood lactate analyzer (Lactate Pro, Arkray, Japan) [Pyne et al., (2000)]. The exercise intensity was increased till participants could not maintain the prescribed stepping frequency.

2.3. Determining the indicators for LA

2.3.1. Determining LT

LT was determined by the method of Beaver, et al. (1985). Briefly, from a graph depicting log-exercise intensity as the independent variable and log-LA as the dependent variable, we divided exercise intensity into pre-LT and post-LT by visual inspection and calculated the regression formula respectively.

\[
\log LA = a_1 \times \log \text{exercise intensity} + b_1 \quad \text{(regression formula for bellow LT)}
\]

\[
\log LA = a_2 \times \log \text{exercise intensity} + b_2 \quad \text{(regression formula for above LT)}
\]

LT was defined as the crossing point of these two straight lines, calculated as follows:

\[
\text{LT (log exercise intensity)} = \frac{(b_1-b_2)}{(a_2-a_1)}
\]

2.3.2. Determination of METs@LaR+0.1 (Figure 1)

METs@LaR+0.1 was determined according to the our previous investigation [Ayabe et al., (2003)]. From each stage, we chose LA bellow and above 2 mmol/l and corresponding exercise intensity. These data was log-transformed, and METs@LaR+0.1 was calculated from straight-line formula.

Data were expressed as mean±SD(95%CI).

*There were significant differences between men and women(p<0.05).
3. Results

Mean ± standard deviations (95% confidence intervals) of METs and LA at LT were 8.6±1.1 (8.2-9.0) METs and 1.2±0.2 (1.1-1.2) mmol/l, and no significant difference was confirmed between men and women (Men vs. Women, 8.4±1.2 METS vs. 8.8 ±1.0 METs, 1.2±0.2 mmol/l vs. 1.2±0.2 mmol/l). In addition, those for METs@LAr+0.1 were 8.7±1.4 (8.2-9.2) METs and 1.2±0.1 (1.2-1.3) mmol/l, and there was no significant difference compared with LT. Error, % Error, SEE, % SEE and TE were, respectively, -0.1±0.5 METs, -0.5±6.7%, 0.44 METs, 5.1% and 0.53 METs.

As shown in Figure 2, a high correlation coefficient was confirmed between LT and METs@LAr+0.1 (r=0.925, p<0.001). Additionally, the lower and upper agreement of difference (mean ±2 standard deviation) were -1.1 METs and 1.0 METs respectively, and were corresponded to -13.2% and 11.6% of LT, respectively.

4. Discussion

Despite one of the best parameter of aerobic capacity, LT has not been generalized because of the frequent blood sampling and/or the skilled techniques accompany with determination. In order to solve these problems, we have proposed a simple assessment of LT that used METs@LAr+0.1 by means of LA obtained from 2 intensities. The accuracy of this assessment was 13.5% (%2SEE of LT) in older people [Ayabe et al., (2003)]. Additionally present investigation demonstrated that this simple assessment had similar accuracy in younger adults. These results clearly indicate that METs@LAr+0.1 can be used in place of LT for the assessment of aerobic capacity and the exercise prescription in younger and older individuals.

Previously exercise intensity of which LA increased 1 mmol/l from baseline level and/or 2 mmol/l of LA had been used as the simple assessment of LT. These simple LT assessment by means of a fixed LA reduces the complications of determining LT. However previous investigations demonstrated that LT evaluated by these assessment was significantly higher than directly determined LT. [Ayabe et al., (2003); Dickstein et al., (1990); Tokmadikis et al., (1998); Yoshida et al., (1987)]. Meanwhile, Beaver, et al. (1985, 1986) have reported that LA at LT in young adults was confirmed between LT and METs@LAr+0.1 with LT. Error, % Error, SEE, % SEE and TE were, respectively, -0.1±0.5 METs, -0.5±6.7%, 0.44 METs, 5.1% and 0.53 METs.

Comparison and correlation of the 2 groups was studied using the paired t-test and Pearson’s correlation coefficient (r). In addition, we studied the agreement between METs@LAr+0.1 and LT using the Bland Altman plots (1986). Furthermore, the estimating accuracy of METs@LAr+0.1 for LT was studied by Error [LT - METs@LAr+0.1], % Error [Mean Error / means of LT × 100], Standard Error of Estimation [SEE, SD√(1-r²)], % SEE [SEE / means of LT × 100] and Total Error [TE, √(Σ(y-r)²/N)]. Obtained data were expressed in mean and standard deviation (mean±SD). For all analysis, significance was set at an alpha level of p<0.05.

2.4. Statistical analysis

Figure 2 The comparison of the lactate threshold and METs@LAr+0.1 in younger adults
LT: lactate threshold. METs@LAr+0.1: METs at which LA increased 0.1 mmol/l from resting level. In the upper graph, the dotted line (...) means the identity line (y=x). The lower graph shows the Bland and Altman plots. The open circles (○) show the difference (LT minus METs@LAr+0.1). The solid line (—) and the dotted lines (...) show the mean and the 2 standard deviation of differences, respectively.
people is proximal to levels at rest. Furthermore, we have confirmed in older people that the increase in LA at LT from rest was 0.1±0.3 mmol/l, and LA was not significantly different between METs@LAr+0.1 and LT [Ayabe et al., (2003)]. Additionally present investigation confirmed similar results in younger adults. Furthermore METs@LAr+0.1 helps to improve the safety, the efficient the cost of exercise test, because the termination criteria is 2mmol/l of LA. These results indicate that 0.1mmol/l above baseline level of LA would be a substitute for LA at LT, and METs@LAr+0.1 has a superior validity and practicality compared with other substitute methods, as the simple assessment of LT.

Since strong correlations with LT have been reported, exercise intensity and/or oxygen consumption at 2 mmol/l or 1 mmol/l above baseline level of LA are valid indicator of aerobic capacity [Ayabe et al., (2003); Dickstein et al., (1990); Tokmadikis et al., (1998); Yoshida et al., (1987)]. However the merits of LT is not only parameter of aerobic capacity, but also the safety and the effectiveness as the training intensity for variety aged and conditioned individuals including chronic patients [Tanaka and Shindo, (1992)]. Thus not only the correlation but also the magnitude of difference compare with LT has important role for the validity of these substitute assessments. However oxygen consumption at 2 mmol/l or 1 mmol/l above baseline level of LA were, in mean, 20 to 50% higher than LT [Ayabe et al., (2003); Dickstein et al., (1990); Yoshida et al., (1987)].

On the other hand, for METs@LAr+0.1, the average value approximated LT (99.5±6.7%), and the limit of agreements with LT were -0.97 to 1.25 METs (-11.30% to 14.55%) in younger adults and -0.80 to 0.77 METs (-17.2% to 16.6%) in older individuals, respectively [Ayabe et al., (2003)]. Thus METs@LAr+0.1 corresponded to 85 to 115% of LT, and it would be a validate training intensity in order to improve the aerobic capacity [Londeree et al., (1997); Swain and Franklin, (2000)] with a superior safety compared to the other alternative assessments (>120% of LT).

In this research, following our previous research [Ayabe et al., (2003)], we assessed LT using a stepping test. Although the stepping test cannot be used for people with lower back problems and similar disabilities, it is a superior graded exercise test in ease, economy and convenience [ACSM, (2000)]. Additionally, widely aged individuals can performed the bench stepping test, because of the usual exercise mode, previous investigations demonstrated that older individuals could perform a bench stepping test with 20cm-platform safely [Ayabe et al., (2003); Furuna et al., (1994)]. Furthermore we reported that 15, 20, 25 and 35 ascends per minute would be the validate stepping rate for bench stepping test with 20cm-platform in order to determine METs@LAr+0.1 in older individuals [Ayabe et al., (2003)]. In present investigation, because of the small sample size and the comparatively high aerobic capacity, the validate exercise intensity for the assessment of METs@LAr+0.1 in younger adults was not established. Hereafter, the validate bench height and/or stepping rate to determine METs@LAr+0.1 must be identified according to the age, sex, fitness level and/or health states, in order to improve the efficiency and the usefulness of this procedure.

5. CONCLUSION

This investigation examined the validity and usefulness of simple assessment of LT, as a part of basics investigation to develop a practical graded exercise test for variety aged and conditioned individuals. Consequently the results of this investigation demonstrated that, as same as older population, METs@LAr+0.1 can estimate LT within ±15% of error in younger adults. Thus we conclude that METs@LAr+0.1 may be valid as a simple assessment of LT for variety aged individuals.

Acknowledgment

We thank the participants, the member at the Laboratory of Exercise Physiology, Faculty of Sports Science, Fukuoka University, and the member at the Laboratory of Human Performance and Fitness, Graduate School of Education, Hokkaido University for their corporation. This investigation was supported by the Special Coordination Funds of Ministry of Education, Culture, Sports, Science and Technology, the Japanese Government.

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