A Correlational Study between 5-minute Run Test and Incremental Treadmill Run Test in Assessing Aerobic Capacity
有氧能力測試的相關研究 - 「五分鐘跑測試」和「遞增負荷跑台測試」

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Abstract

The purpose of this study was to determine the relationship between the 5-minute run test and the incremental treadmill run test in assessing aerobic capacity. Twenty subjects participated in this study. The maximum oxygen uptake was estimated by the 5-minute run test and directly measured by the incremental treadmill run test. Correlations were computed by the SPSS Pearson procedures. Linear regression analysis was utilized to predict the 5-minute run test scores based upon the incremental treadmill run test results in determining maximum oxygen uptake. Significant relationship was found between two tests in assessing maximum oxygen uptake. Simple linear regression showed that running velocity in 5-minute run was a significant predictor for maximum oxygen uptake measured in the incremental treadmill run test. To conclude, the 5-minute run test was valuable to predict maximum oxygen uptake.

摘要

本文旨在探討兩種評估有氧能力的測試：「五分鐘跑測試」和「遞增負荷跑台測試」之關係。是次研究共有二十位受試者參與，在實驗室進行遞增負荷跑台運動測量其標準的最大攝氧量，用「五分鐘跑測試」來推測和評估其最大攝氧量，所得的資料以相關和直線回歸法分析，從而探求「五分鐘跑測試」和「遞增負荷跑台測試」之關係。研究結果顯示兩種評估有氧能力的測試有密切的關係；此外，研究員利用五分鐘平均跑速推算出最大攝氧量的回歸方程。

Introduction

According to Ensrud and Folsom (1985), aerobic capacity is the most important component of physical fitness and the best indicator of overall health. It is because the status of aerobic capacity is linked with the potential risks of coronary heart disease, stroke as well as hypertension. As a result, evaluating aerobic capacity plays a prominent role in detecting possible risks of getting such life-threatening diseases.

For this reason, tests for aerobic capacity strike their high popularity. Numerous studies have investigated that maximum oxygen uptake is the best indicator of aerobic capacity. For the sake of assessing maximum oxygen uptake, Jackson, Sanchez, Schick and Weduwe (1990) stated that maximal exercise testing carried out in laboratory was the most precise way to determine maximum oxygen uptake. And thus, it provided the most accurate determination of aerobic capacity. Direct assessment of maximum oxygen uptake by laboratory test was through direct gas analysis. This was done with the utilization of a metabolic cart through which the amount of oxygen consumption could be directly measured. When undergoing maximal exercise laboratory test, some standardized protocols on the treadmill, leg or arm ergometer would be carried out. Common measurement procedures include Branching protocol, Ellestad protocol, Kattus protocol and Treadmill Time Test (Blair, Eddy, Painter, & Wolfe, 1991).

With regard to Buono, Micale, Roby, Sallis and Shepard (1991), despite a high level of accuracy in determining aerobic capacity, maximal exercise laboratory test was generally not applicable for most public school settings, health promotion programs, or epidemiological field studies. This was because using maximal exercise laboratory test to assess maximum oxygen uptake was time consuming, expensive, required bulky instrumentation

and trained techniques. Thus, all such precise testing procedures make it impossible for collecting data from a large number of subjects at one time, like during regular school PE classes.

Since maximal exercise laboratory test was not a practical method of assessing aerobic capacity for vast population, numerous field tests have been developed. In contract to laboratory test, Hassmen (1995) stated that field test eliminated the need for costly apparatus such as cycle ergometer or treadmills. Anderson (1992) and Cooley, Kearney, Naughton and Smith (1996) also supported the field tests for measuring a large number of subjects at one time. Therefore, field tests gain a great deal of popularity in schools and health clubs, where expensive equipment is not usually available.

According to Gauthier, Markon and Massicotte (1985), Cooper's 12-minute run test is the most common field test in predicting maximum oxygen uptake. Participants are required to run as the longest distance as they can in 12 minutes so as to predict their maximum oxygen uptake. In the study of Giese et al. (1990), the validity coefficients of the Cooper 12-minute run test ranged from 0.65 to 0.90. The lower sizes of some coefficients might be due to a lack of motivation in the performance of the distance runs, body fatness or running inefficiency.

Although the Cooper's 12-minute run test was easy to administrate and had a recognized validity, it was quite stressful for the participants, as they were required to perform his/her maximal effort throughout the test (Hoeger, 1991). Recently, several studies were undertaken to investigate the validity of the 5-minute run test. Its major advantage is to shorten the testing time which is rather user-friendly in school settings. Beaune, Bedu, Berthon, Chamoux, Coudert, Dabonneville and Fellmann (1997) had demonstrated a significant correlation between the 5-minute run test and maximum oxygen uptake ($r = 0.94$, $p < 0.001$).

Despite the 5-minute run test still required the subject to perform in maximum effort, it was comparatively less stressful than the Cooper's 12-minute run test. Thus, there exists a room to examine the correlation between the 5-minute run test and the traditional laboratory-use incremental treadmill run test for the purpose of establishing an acceptable reliability coefficient in assessing aerobic capacity, particularly in Chinese subjects.

The purpose of this study was to validate the recent 5-minute run test by utilizing the traditional treadmill run test as the criterion. If such reliability exists, the recent developed 5-minute run test can then be introduced to a wide range of school settings in order to accurately assess the aerobic capacity.

Method

Subjects

Twenty healthy male university students from the Hong Kong Baptist University were the subjects in this study. Simple anthropometric measurement was also collected prior to the test, including body height and weight.

Instruments

Aerobic capacity of each subject was shown in terms of the maximum oxygen uptake and it was measured by the incremental treadmill run test conducted in the Dr. Stephen Hui Research Centre for Physical Recreation and Wellness. In this test, a monitored treadmill with adjustable grade and speed was used. The SensorMedics system, Quinton Series 90 treadmill and Model 645 controller were utilized. Also, Polar NX heart rate monitors were worn to collect heart rate data throughout the test. In addition, rating of perceived exertion scales (RPE) was asked the subjects to response which served as a mean to quantify the participants' sensations to the test.

Procedures

Each subject was required to complete both the 5-minute run test and the incremental treadmill run test. One week rest period was given between such two assessments in order to avoid any fatigue effect. All subjects was given an explanation of the testing before signing the informed consent forms,

The incremental treadmill run test was conducted at the Dr. Stephen Hui Research Center of Physical Recreation and Wellness. The test session last about forty-five minutes. Each subject was provided sufficient warm up and cool down throughout the testing. The speed and gradient of the treadmill were adjusted stage by stage. Oxygen consumption was measured using an open circuit technique. At the initial stage, the running speed was based upon a 70% of the estimated maximal heart rate of the subject and zero gradient was selected. Each stage would be proceeded after a two-minute running period. The gradient would also be increased by 2%. When the subject reached 90% of his maximal heart rate, the running time for the stage would be adjusted to one minute until exhaustion occurred. The VO_2 was collected at the last 20 seconds of each stage.

After participating in the incremental treadmill run test, subjects had to engage in the 5-minute run test after one week rest period. The 5-minute run test was taken place at a 400m standard all weather track located at the Joint Sport Center of

the Hong Kong Baptist University. Subjects are required to run as hard as they could and cover the maximum distance within five-minute testing period. They were recommended to have steady running with constant paces. At the last ten seconds, a count down was given. Moreover, intermediate times at 400m and 800m marks were recorded and heart rates of subjects will also be taken before, during and after the test. No rest was allowed during the test.

Data Analysis

All data were treated utilized the procedures from the SPSS 9.0 version. Descriptive analysis were also conducted, such as the means, standard deviations, minimum and maximum values of the variables. Pearson r correlation coefficients were used to determine the correlations among variables. In addition, linear regression analysis was applied to predict the maximal oxygen uptake according to the obtained data. Stepwise method was selected to determine the possible combination of independent variables that provides the optimal prediction of maximum oxygen uptake. An alpha level of 0.05 was used for all significance tests.

Results

The physical characteristics of the subjects were presented in Table 1. The descriptive statistics of the 5-minute run test was shown in Table 2.

Table 1. The Physical Characteristics of the Subjects (N=20)

	Mean (SD)	Minimum	Maximum
Age	20.85 (1.35)	19	24
Height (cm)	172.6 (5.65)	164	188
Weight (kg)	63.63 (8.15)	51.5	83.5

Table 2. Descriptive Statistics of the 5-minute Run Test.

	Mean (SD)	Min	Max
Distance covered (m)	1264.43 (101.84)	1000.2	1423.8
Running velocity (km/h)	15.17 (1.22)	12	17.09
Estimated maximum oxygen uptake (ml/kg/min)	52.18 (4.31)	41.07	58.99
HR at 400m	179 (12)	138	193
HR at 800m	183 (12)	148	199
HR at time of completion	186 (12)	152	202

The distance which subjects covered ranged from 1000. 2 to 1423.8 m. The mean and standard deviation of distance completed by them were 1264.43 m ± 101.84. Furthermore, the mean running velocity was 15.17 km/h, with a standard deviation ± 1.22. The estimated maximum oxygen uptake of the subjects ranged from 41.07 to 58.99 ml/kg/min. The mean and standard deviation of estimated maximum oxygen uptake were 52.18 ml/kg/min ± 4.31. Besides, the mean heart rate recorded after subjects completed 400 m was 179, with a standard deviation = ± 12. The mean heart rate recorded after subjects completed 800 m was 183, with a standard deviation = ± 12. On the other hand, the mean heart rate recorded immediately after subjects completed the 5-minute run test was 186, with a standard deviation = ± 12.

The descriptive statistics of the incremental treadmill run test was presented in Table 3.

Table 3. Descriptive Statistics of the Incremental Treadmill Run Test.

	Mean (SD)	Min	Max
Measured maximum oxygen uptake ($ml.kg^{-1}.min^{-1}$)	54.68 (6.14)	40.57	63.93
Maximum heart rate	194 (10)	169	210

The measured maximum oxygen uptake ranged from 40.57 to 63.93 ml/kg/min. The mean and standard deviation of measured maximum oxygen uptake were 54.98 ml/kg/min ± 6.14. Above all, the mean maximum heart rate recorded was 194, with a standard deviation ± 10.

Furthermore, ten variables were analyzed by Pearson product moment coefficient correlation to determine whether correlations were found or not. Correlation results and its significance among variables were shown in Table 4.

Table 4. Pearson r among All Variables.

	W	H	D	RV	VO_{2max}–5	HR-400	HR-800	HR-com	VO_{2max}–I	M. HR
W	1.000	0.572**	0.248	0.248	0.247	-0.670**	-0.767**	-0.832**	-0.43	-0.549*
H	0.572**	1.000	0.10	0.009	0.009	-0.546*	-0.447*	-0.567**	-0.299	-0.494*
D	0.248	0.10	1.000	1.000**	1.000**	-0.219	-0.142	-0.34	0.765**	0.74
RV	0.248	0.009	1.000**	1.000	1.000**	-0.218	-0.142	-0.33	0.765**	0.075
VO_{2max} –5	0.247	0.009	1.000**	1.000**	1.000	-0.219	-0.141	-0.033	0.763**	0.075
HR-400	-0.670**	-0.546*	-0.219	-0.218	-0.219	1.000	0.895**	0.814**	-0.013	0.615**
HR-800	-0.767**	-0.447*	-0.142	-0.142	-0.141	0.895**	1.000	0.869**	-0.016	0.620**
HR-com	-0.832**	-0.567**	-0.034	-0.033	-0.033	0.814**	0.869**	1.000	0.165	0.787
VO_{2max} –I	-0.043	-0.299	0.765**	0.765**	0.763**	-0.013	-0.016	0.165	1.000	0.399
M. HR	-0.549*	-0.494*	0.074	0.075	0.075	0.615**	0.620**	0.787**	0.399	1.000

Note:

** : Correlation was significant at the 0.01 level (2-tailed)

* : Correlation was significant at the 0.05 level (2-tailed)

W : Weight

H : Height

D : Distance covered in the 5-minute run test

RV : Running velocity in the 5-minute run test

VO_{2max} –5 : Maximum oxygen uptake estimated by the 5-minute run test

HR-400 : Heart rate at 400 m

HR-800 : Heart rate at 800 m

HR-com : Heart rate at the completion of the 5-minute run test

VO_{2max} –I : Maximum oxygen uptake measured by the incremental treadmill run test

M. HR : Maximum heart rat recorded in the incremental treadmill run test

The measured maximum oxygen uptake had a significant and positive correlation with distance covered by subjects (r = 0.765) and running velocity (r = 0.765) in the 5-minute run test, at the 0.01 level. Moreover, significant ($p < .01$) correlations were observed between the estimated maximum oxygen uptake and measured maximum oxygen uptake. Firstly, heart rate recorded after subjects completed 400 m and 800 m showed a very significant correlation (r = 0.895). Meanwhile, the heart rate recorded immediately after subjects finished the 5-minute run test had a positive correlation with heart rate recorded after the completion 400 m (r = 0.814) and the completion of 800 m (r = 0.869).

Allied with this, the simple linear regression analytical results were shown in Table 5 and 6.

Table 5. Simple Linear Regression Analytical Results: Model Summary.

Dependent Variable	Predictor	Model summary			
		R	R^2	Adjusted R^2	SEE
Measured VO_{2max}	Running Velocity	0.765	0.585	0.562	4.063

Table 6. Simple Linear Regression Analytical Results Using ANOVA.

Dependent Variable	Predictor	ANOVA				
		Sum of Square	df	Mean Square	F	Sig.
Measured VO_{2max}	Running Velocity	419.188	1	419.188	25.387	0.000

Discussions

A significant relationship existed between the estimated maximum oxygen uptake of the 5-miunte run test and the incremental treadmill run test. ($r = 0.763$, $p < 0.01$). Similar observation has been reported by Beaune et al. (1997). In their study, a strong correlation was found between the maximum oxygen uptake predicted by the 5-minure run test and the maximum oxygen uptake assessed by the incremental treadmill run test ($r = 0.94$, $p < 0.001$).

The relationship between two tests in assessing aerobic capacity could have been due to the specific procedures of the 5-minute run test. Buono et. al. (1991) indicated that the duration of five minutes would seem quite satisfactory for evaluation aerobic capacity. It was the optimal time and minimal duration necessary to summon the maximal aerobic component with a reduced anaerobic involvement.

However, underestimation of maximum oxygen uptake was found in the 5-minute run test when compared with the results of the incremental treadmill run test. This situation would be explained by two reasons. First, the subjects might be under-motivated during the field test evaluation. Jackson et al. (1990) stated that the degree of motivation of subjects in performing field tests was difficult to control. Although subjects in this study were strongly suggested to exert their maximal effort in the 5-minute run test by maintaining their exercise heart rate over 80% of their predicted maximum heart rate, however, their performances were still influenced by their self-generated motivation.

Second, subjects in this study were not elite runners. Hence, subjects might not be able to utilize the optimal efficient running economy in the 5-minute run test which would contribute to an error in the estimation of maximum oxygen uptake. This was also observed by Freedson, Rippe, Ward, Wilke and Zwiren (1991) who found that underestimation was due to poorer running velocity by comparing the results of using cycle ergometer.

From the linear regression analysis, running velocity was considered as the most significant predictor of measuring the maximum oxygen uptake ($r = 0.765$, $p < 0.01$). Similar observation was found by Beaune et al. (1997), which stated that the 5-minute run test was a good measurement of aerobic capacity. Besides, Croft, Long, Macnaughton and Pennicott (1990) also supported the present finding. They observed that the 5-minute run test gave a satisfactory estimation of aerobic capacity ($r = 0.661$, $p < 0.01$). An predictive equation for measured maximum oxygen uptake from running velocity in the present 5-minute run test was established:

Measured maximum oxygen uptake = 3.8422 (running velocity) - 3.3121

Conclusions

Running velocity derived from the 5-miute run test is valuable to estimate the maximum oxygen uptake of participants in this study. Further research is needed to cross validate this newly established equation on a greater number of subjects with different gender and phyical characteristics.

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