Comparison of VO_2 Max Prediction Value, Physiological Response, and Borg Scale between 12-Minute and 3200-Meter Run Fitness Tests among Indonesian Army Soldiers

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Abstract

Objective: To compare the VO_2 max and physiological responses between 12-minute and 3200-meter run fitness tests.

Methods: The subjects were 40 soldiers aged 18–21 years old of the Infantry Battalion 303/SSM of Cikajang, Garut, West Java, Indonesia. The 12-minute and 3200-meter run fitness tests were conducted with one week resting period. The measurement of the VO_2 max prediction was based on each of the formulations and the measurement of physiological response included blood pressure, heart rate, respiratory rate, Borg scale and oxygen saturation before and after the tests. This study used a cross-sectional method while the data were analyzed statistically using t-test (p=0.05).

Results: The results showed that the VO_2 max prediction in 12-minute run fitness test was 52.046±2.980 mL/KgBB/min and the 3200-meter run test was 55.323±3.238 mL/KgBB/min. The value was statistically significant (p=0.008). There was no significant difference in the physiological response in both tests, except the SpO_2 parameter after the tests (p=0.021).

Conclusions: There is a significant difference in VO_2 max prediction between 12 minutes and 3200 meter run test. No significant difference was found in the physiological response in both tests, except the SpO_2 parameter.

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Introduction

Due to the duty, both in training and operation fields, the military agencies in all over the world always seek new protocols to ensure maximum physical conditions of every soldier. The capabilities possessed by a soldier make him to be considered as "A Tactical Athlete" or an individual who requires a high level of strength, speed, and dexterity.[1,2]

One of several efforts to maintain and increase the degree of physical condition of a soldier is by conducting a physical fitness test to monitor the soldier's physical fitness that the soldiers achieve strong physical endurance and are prepared for every duty.[3,4] One of the components of physical fitness that plays a very important role is the cardiorespiratory endurance or aerobic capacity.

The cardiorespiratory endurance can be measured by measuring the maximum oxygen consumption (VO_2 max).[4] The value of VO_2 max depends on the conditions of cardiovascular, respiratory, hematology, and muscle oxidative capacity.[5,6]

The VO_2 max can be measured using exercise testing, using Coopertest or 12-minute run/walk fitness test. The test is performed by subjects through running or walking as fast as possible for 12 minutes then the mileage is converted to VO_2max.[7] In addition, there is also a 3200-meter run fitness test that is, running for 3200 meters. The running time is then converted to VO_2 max. A study conducted on Croatian males with 3200-meter run

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fitness test was considered valid and accurate to predict the value of VO_2 max.[2] Another study was conducted on the soldiers of Royal Malaysian Navy (RMN) aiming to calculate body composition and the degree of physical fitness during the training with 2.4-kilometer run test.[8] There was a significant relationship between body fat percentage and body mass index (BMI) with 2.4-kilometer run test. In this study, a significant inverse correlation was found between VO_2 max and body fat composition.

The implementation of the physical fitness test of Indonesian army is regulated by the Chief of Army regarding the soldier physical preparedness norm implementation. The 12-minute run fitness test, in Indonesia, was replaced by 3200-meter run fitness test.[9]

A physiological response is regarded as a certain reaction causing physical responses, including those reflected in blood pressure and pulse. Psychologically, the 3200-meter run fitness test is easier and more manageable in terms of the run rhythm and strategy because the mileage basis is set compared to time basis, and with this the value of physical fitness is getting better.[10,11]

However, it is unknown whether there are differences between the VO_2 max prediction and physiological responses manifested in both tests. This study aimed to examine the differences in VO_2 max prediction, physiological response, and Borg scale between 12-minute and 3200-meter run fitness tests among the Indonesian army soldiers.

Methods

The subjects of the study were the Indonesian army soldiers stationed in Infantry Battalion 303/SSM Cikajang, Garut, West Java, Indonesia with the age of 18–21 years old, no systolic blood pressure of >140 or <90 mmHg and no diastolic blood pressure of >90 mmHg or <70 mmHg during resting, pulse >100 beats/minute, and consenting to follow the procedures of 12-minute and 3200-meter run fitness tests by signing an informed consent form. The subjects took physical examination and anthropometric measuring leading to 40 subjects in total. The measurements of vital signs, oxygen saturation with pulse oximetry, the Borg scale were conducted before and immediately after the exercise testing. The exercise testing was applied in 2 steps with one week interval for the same subjects and location. The result of the 12-minute run fitness test, that was mileage, was converted to VO2 max with the formulation[7]:

$$VO_2 \text{ max} = (\text{Mileage in meters} - 504.9)/44.73$$

The running time taken from 3200-meter run fitness test was converted to VO2 max through the formulation[12]:

$$VO_2 \text{ max (mL.kg.min)} = 118.4 - 4.774 \text{ (mileage)}$$

The comparison of the VO_2 max prediction from both tests was analyzed statistically by using Mann-Whitney test and the comparison of the physiological response and Borg scale used Wilcoxon Matched Pairs test. The Mann-Whitney test was used to compare the different values between 12-minute and 3200-meter run fitness tests. Wilcoxon Matched Pairs test was performed to compare two related variables.

Results

The characteristics of the subjects were examined to measure their physical fitness (Table 1). The normally distributed data used Mean±SD, while the non-normally distributed data used median (minimum-maximum).

Table 1 Subject Characteristics

Variable	Subject (n=40)		p Value
	Mean ± SD	Median (min–max)	
Height	-	170 (166–172)	0.005
Weight	-	63 (57–68)	0.034
Age	-	21 (20–21)	0.077
Body mass index	21.7275±0.998457	-	0.000

Body mass index (kg/m2)

In the normality test of the VO_2 max data, non-normally distributed data was found; therefore, the Mann-Whitney test was used to compare the VO_2 max prediction between the 12-minute and 3200-meter run fitness tests. The result of the Mann-Whitney test is shown (Table 2).

The significant difference in terms of the VO_2 max prediction between the 12-minute and 3200-meter run fitness tests was found with p=0.0000 and a degree of reliability of 95%. The 3200-meter run fitness test revealed that the VO_2 max prediction value was lower than that tof the 12-minute run fitness test.

The depiction of the physiological response before and after both tests is presented (Table 2). There were insignificant statistic results found in all different variable for the 12-minute run fitness test, while in the 3200-meter run fitness test, the SpO_2 was not significant. However, other variables were considered statistically significant.

Significant difference in Borg scale values in before and after the 12-minute and 3200-meter run fitness tests were found (Table 3). The comparison between before and after the 12-minute and 3200-meter run fitness tests was considered statistically insignificant.

The comparison of physiological response and Borg scale between the 12-minute and 3200-meter run fitness test before and after the tests were analyzed (Table 4). It turned out that the only significant different was SpO_2 after the tests. Borg Scale shows no significant difference in the result between the 12-minute and 3200-meter run fitness tests.

The increase in the physiological response between both run fitness tests was described (Table 5). The significant difference in the result was only found in SpO_2. The SpO_2 value was higher in the 12-minute run fitness test.

Discussion

The characteristics of body weight and height are homogenous (Table 1). The average weight was 63 kg in median and the average height was 170 cm in median. Therefore, the body weight and height parameters will not have significant effect on the VO_2 max prediction value resulted from both tests. Body weight affects the VO_2 max prediction result according to the correlation strength between VO_2 max and body.[2] The body height affects as well the VO_2 max value, because body height parameter is one of the predictors of VO_2 max value.[10]

The value of VO_2 max prediction in this study was taken from submaximal test of both 12-minute and 3200-meter run fitness tests. Both of these tests have similar characteristics namely easy and cheap for implementation as well as having a competitive atmosphere because they involve subjects together and they need subjects' motivation to complete the tests. The result of VO_2 max prediction in 3200-meter run fitness test is higher than the result of VO_2 max prediction in the 12-minute run fitness test and there was a significant difference with p value of 0.0000. The VO_2 max prediction was higher in 3200-meter run fitness test due to the strategy in managing mileage efficiency, speed and effort required to complete the test or known as the pacing strategy. This strategy may prevent fatigue so that the physical performance enhances and the mileage becomes better.[13] The 12-minute run fitness test requires a strong motivation

Table 2 The Comparison of Physiological Response Before and After Both Run Fitness Tests

Variable	12-Minute Run Fitness Test			3200-Meter Run Fitness Test		
	Before (Median)	After (Median)	p Value	Before (Median)	After (Median)	p Value
Systolic	100 (90–120)	130(110–160)	0	102.5±10.8012*	129.5±19.6051	0
Diastolic	70 (50–90)	80 (60–120)	0.0154	70 (60-90)	80 (60-130)	0.0091
Pulse	72.775±10.3267*	124 (94–177)	0	74.5±8.0128*	127 (75–167)	0
Respiratory rate	20.45±4.1197*	33.45±7.8019*	0	21.075±4.1224	34 (94–177)	0
SpO_2	98 (96–99)	95 (85–98)	0.0082	98 (98–99)	97 (86–98)	0.9374

Table 3 The Comparison of Borg Scale Before and After Both Run Fitness Tests

Variable	12-Minute Run Fitness Test			3200-Meter Run Fitness Test		
	Before (Median)	After (Median)	p Value	Before (Median)	After (Median)	p Value
Effort	9 (1–13)	13 (6–17)	0.0000	9 (1–13)	13 (1–19)	0.0000
Asphyxiation	0 (0–10)	3 (0–19)	0.0000	1.5 (0–7)	4 (0–7)	0.0000
Leg fatigue	0.5 (0–5)	3 (0–7)	0.0000	1.5 (0–5)	4 (0–10)	0.0000

and better efforts to complete the test. The subjects may have an impression as if they run against time, which then leads to extreme fatigue and reducing physical performance. Thus, the target of the mileage does not meet the maximum expectation and the VO_2 max resulted lower value.[11]

The result is contrast with a study by Grant which compared the results of the VO_2 max prediction between 12-minute walk test, multistage shuttle run test, and submaximal test using cycle ergometer with direct VO_2 max measurement method by ventilator gas and treadmill.[14,15] This study revealed that the VO_2 max prediction with 12-minute walk test had a strong correlation (0.92) with the result of VO_2 max taken through direct method. This difference is possibly caused by the fact that the VO_2 max prediction result in Grant's research is bigger compared to this study with different range age of sample.[14,15]

The limitation of this study is that the tests result taken from VO_2 max measurement using ventilator gas was not compared. Therefore, it is unknown of both these methods resulting closely to the actual VO_2 max.

The physiological responses of both tests show insignificant differences, except for the SpO_2 values (Table 4). The data show that the 12-minute and 3200-meter run fitness tests may cause similar responses in blood pressure, respiratory rate, and pulse. The subject responses showed similar results in both tests which were considered statistically

Table 4 The Comparison of Physiological Response and Borg Scale between the 12-Minute and 3200-Meter Run Fitness Tests

Variable	12-Minute Run Fitness Test (n=40)		3200-Meter Run Fitness Test (n=40)		p Value
	Before (Median)	After (Median)	Before (Median)	After (Median)	
Systolic before	-	100 (90–120)	102.5±10.8012	-	0.935
Systolic after	-	130(110–160)	129.5±19.6051	-	0.8286
Diastolic before	-	70 (50–90)	-	70 (60–90)	0.9731
Diastolic after	-	80 (60–120)	-	80 (60–130)	0.7655
Pulse before *	72.775±10.3267	-	74.5±8.0128	-	0.4065
Pulse after	-	124 (94–177)	-	127 (75–167)	0.8701
Respiratory rate before*	20.45±4.1197	-	21.075±4.1224	-	0.4996
Respiratory rate after	33.45±7.8019*	-	-	34 (94–177)	0.06
SpO_2 before	-	98 (96–99)	-	98 (98–99)	0.9425

*Normally distributed data, the rest was non-normally distributed data

Table 5 The Differences of Physiological Response Increasing in the 12-Minute and 3200-Meter Run Fitness Tests

Variable	12-Minute	3200-Meter	p Value
Systolic	20	27	0.954
Diastolic	10	10	0.693
Pulse	51.2	52.5	0.497
Respiratory	13	12.9	0.1157
SpO_2	3	1	0.0179

insignificant based on Borg scale. This is a hemodynamic response to the exercise according to increased cardiac output to fulfill the oxygen need.[16] The oxygen saturation in the 12-minute run fitness test shows a significant difference value decrement compared to the 3200-meter run fitness test. The 3200-meter run fitness test shows no significant reduction change in SpO_2 value.

The oxygen saturation is an indicator of hemoglobin percentage saturated with oxygen during the measurement. This does not describe the oxygenation status.[16] The oxygen saturation decrement with oxymetry pulse measurement may imply exercise-induced hypoxemia.[17] A study found that hypoxemia occurs when SpO_2 is decreasing from 97% to 92%.[18] Another study also reported that minor exercise-induced hypoxemia may occur when the SpO_2 decreases to 93–95% (3–4%) since resting, from resting with the moderate occurs in 88–92% since resting and the major one occurs when a decrease from 88% happens.[19]

The present study found that there was a significant decrease only for about 3% in the 12-minute run fitness test which can be lead to a suggestion that the 12-minute run fitness test causes minor hypoxemia. Compared to the 3200-meter run fitness test, the 12-minute run fitness test causes the decrease of oxygen level saturated with hemoglobin. This is due to the fact that the 12-minute run fitness test reaches anaerobic threshold faster causing the decreasing of oxygen level and this is the factor affecting the aerobic performance decreasing leading to lower VO_2 max value.[18]

The observation of oxygen saturation using the oxymetry pulse is also a limitation of this study. This due to the fact that this equipment has a different sensitivity level, depending on the levels of hemoglobin, blood flow, fingers temperature, individual oxygenation capability, venous return and sensor capability.[18]

In conclusion, there are differences of VO_2 max prediction value between the 12-minute and 3200-meter run fitness tests. The value of VO_2 max prediction is higher in the 3200-meter run fitness test. There are no significant differences of physiological response between both tests except for the SpO_2 value which significantly decreases in the 12-minute run fitness test.

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