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VALIDITY OF 2-MILE RUN TEST FOR DETERMINATION OF VO_{2MAX} AMONG SOLDIERS

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ABSTRACT

Objectives: The aim of this study was to determine the validity of the 2-mile run test as the predictor for the assessment of maximum oxygen consumption (VO_{2max}) of soldiers. **Methods**: The study was conducted on a sample of 409 Members of Croatian Armed Forces (age 29.10 ± 5.60 years; height 179.44 ± 6.62 cm; body mass 82.39 ± 11.25 kg). The two-mile run was used to assess the aerobic fitness and leg muscles' endurance. **Results**: The results have shown that there was statistically significant correlation between the 2-miles run test and maximal oxygen consumption on absolute level (r = -0.385; $p < 0.01$), as well as for the relative values (r = 0.639; $p < 0.01$). Besides this, the 2-miles run test has shown correlation with body mass ($p < 0.01$), as well as with the age of participants (r = 0.230). There was no significant correlation between body height and the 2-miles run test (r = 0.061; p = 0.21). **Conclusion**: It can be concluded that 2-mile run test protocol is fairly accurate and valid to predict the VO_2max values in male military participants. This field test is also applicable to a great number of participants, taking into consideration the variability in age and beginning level of physical preparation for every soldier.

Keywords: military, predicting, maximal oxygen uptake, reliable

INTRODUCTION

Military has been always searching for new ways to prepare the soldier for rigorous demands of battle field. During history different ways of organizing, equipping, operating and training have been developed with one cause and goal, to be better than opponent and to beat him. Nowadays, because of the development of many areas and new facts, the science approach is more frequent in determination of basic program and training structure, which have the goal to train and prepare the soldiers for modern combat demands. That knowledge is based on the science methodology and information provided by the researches. For this kind of scientific fact it is necessary to select the proper tests in order to provide the information of soldiers' level. There is a great interest for researching the soldiers' status concerning the condition skills, and above all the aerobic endurance[1-4]. Training content for

the development of aerobic endurance is part of almost all military training. However, there is a problem of choosing the adequate test for determination of aerobic endurance. Since the soldiers' testing procedure demands great number of participants, the practical implementation of some tests is limited.

Throughout the last decades numerous sport-motoric tests have been used in the military to assess soldiers´ physical performance and fitness[5-8]. To be widely used, the test must be applicable for big unhomogen groups of each level and gender[7-11]. Data acquisition and analysis had to meet all prerequisites and requirements for modern quality management, including scientific research for continuous evaluation and adaptation. The determination of aerobic capacity in the laboratory is time consuming and requires technical personnel and sophisticated instrumentation. Hence, attempts have been made to specify a field test that has a good correlation with VO_{2max}[12-14]. A few studies had been conducted in order to establish a field test as a predictor of aerobic endurance. One such study had been conducted by Malhotra et al. in order to establish the long distance cycling time trial as a predictor of VO_{2max}[15]. The athletic events are a good example of test that is based on field performance. In such events the performance can be measured either by distance covered in a specified time or by time taken to cover a specific distance.

One of the most common tests for determination of aerobic endurance and VO_{2max} of soldiers is the 2-mile run test. It represents one of the three parts of The Army Physical Fitness Test (APFT), that is used by the NATO members for determination of muscular endurance and cardio-respiratory fitness[16]. The duration of the test is 25 minutes[17] and the number of its participants depends of the track and terrain configuration.

Therefore, the aim of this study was to determine the validity of the 2-mile run test as the predictor for the assessment of maximum oxygen consumption (VO_{2max}) of soldiers.

METHODS

Participants

The population from which the sample of this study was selected is the third generation of Croatian Armed Forces military recruits. For the purpose of this study 409 Members of Croatian Armed Forces (age 29.10 ± 5.60 years; height 179.44 ± 6.62 cm; body mass 82.39 ± 11.25 kg) were tested. Ethics Committee of the Faculty of Kinesiology, University of Zagreb approved the study. All participants were submitted to health examination before the testing and only the ones with adequate health status and doctor permission were allowed to participate in the study. The pharmacological regimen of the participants was considered and participants who were in the recovery phase of an acute or chronic illness were excluded. The research does not include participants with cardiovascular system disorders because of the potential risks during the functional fitness tests. This research is part of the project "Investigation of human resources and potential" implemented by the Ministry of Defence of the Republic of Croatia and in collaboration with the Faculty of Kinesiology, University of Zagreb. Recruits voluntarily participated in the study, were carefully informed about the study and signed a written consent before the experiment. All experimental procedures were approved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb. The participants were aware that they could withdraw from the study at any time they want. There was no supplement addition regarding the nutrition of soldiers. None of the participants were injured 6 months before the initial testing as well as during the

training program. In addition, participants were not taking exogenous anabolic-androgenic steroids and other drugs that might be expected to affect physical performance or hormonal balance during this study.

Procedures

Laboratory assessments were undertaken at the Faculty of Kinesiology, University of Zagreb, Croatia. Each soldier was measured by experienced anthropometrics prior to the measurement of VO_{2max}. Body mass was assessed to the nearest 0.1 kg using SECA Beam Balance Scale 700 (SECA GmBH & Co, Hamburg, Germany) with the athletes wearing minimal clothing. Body height was assessed to the nearest 0.1 cm using portable SECA Stadiometer 282 (SECA GmBH & Co, Hamburg, Germany). The stadiometer and scale were calibrated periodically during the study.

The testing was conducted within intervals of four days. Laboratory assessment of VO2max was carried out as an independent activity during the first day. After direct assessment of maximal oxygen uptake (on motor-driven treadmill) two day of rest has followed to eliminate potential accumulation of fatigue. The fourth day was spent measuring the variables for the assessment of muscular endurance and aerobic endurance assessed by two-mile run test. The measurement was carried out by the basic training instructors for special operations for both tests. Each participant performed a standardized 15 minute warm-up consisting of general movements and dynamic and static stretching. Participants were performed the same warm up protocol before each test.

Maximal oxygen uptake test

To prevent unnecessary fatigue accumulation, participants were asked to refrain from strenuous exercise for 24 h prior to exercise test. After warm-up and stretching, based upon the participant's habits, VO_{2max} was measured by standard incremental maximal exercise test protocol that was performed on a motor-driven treadmill (Run race, Technogym, Italy) with a 1.5% inclination was applied. During the testing period the air temperature ranged from 21°C to 23°C The testing was performed in morning hours (between 9 am and 13 am) in thermo-neutral conditions. After 1 minute of measuring VO_2 in rest (standing position), the starting speed was 3 km/h, with speed increments of 0.5 km/h every 30 seconds. The participants walked the first few steps (up to 6 km/h), and continued running from 7 km/h, until volitional exhaustion. Expired gas was sampled continuously and O_2 and CO_2 concentration in expired gas were determined using stable and fast Zirconium Oxygen and NDIR Carbon Dioxide analyzers (breath-by-breath gas exchange system Quark b^2, COSMED, Italy) which were calibrated prior to and following each test using precision reference gases. The system was calibrated before each test using gases of known concentrations. Heart rate (HR) was collected continuously during the tests using telemetric heart rate monitor (Polar Electro, Kempele, Finland), and stored in PC memory. Expired airflow was measured with digital turbine flow meter (COSMED, Italy), which was calibrated prior to and following each test using a 3 l syringe at flow rate and volumes in the expected physiological range. Temperature and humidity of expired gas were measured using a rapidly-responding sensor (Quark b^2, COSMED, Italy). End-of-test criteria for the determination of maximal oxygen uptake (VO_{2max}) included two of the following: 1) volitional exhaustion, 2) achieving a plateau in VO_2 (highest values were calculated as arithmetic means of the two consecutive highest 30s values), and 3) HR $\geq$ 90% of age-predicted maximum. All

participants refrained from exercise for 24 h before testing. During recovery after test protocol, the participants walked at 5 km/h for 2 minutes. The last half or full stage the participant could sustain (for either 30 s) was defined as the participant's maximal speed.

Two-Mile Run test

The two-mile run is used to assess aerobic fitness and leg muscles' endurance. Recruits must complete the run without any physical help. At the start, all soldiers will line up behind the starting line. On the command 'go,' the clock will start. Soldiers will begin running at your own pace. They are being tested on own ability to complete the 2-mile course in the shortest time possible. Although walking is authorized, it is strongly discouraged. If they are physically helped in any way (for example, pulled, pushed, picked up, and/or carried) or leave the designated running course for any reason, they will be disqualified. It is legal to pace a soldier during the 2-mile run. As long as there is no physical contact with the paced soldier and it does not physically hinder other soldiers taking the test, the practice of running ahead of, alongside of, or behind the tested soldier, while serving as a pacer, is permitted. Cheering or calling out the elapsed time is also permitted. Players underwent physical tests assessments in an outdoor stadium. During the test air temperature ranged from 22°C to 25°C. It began at 10 am and finished by 1 pm.

Statistical analysis

The collected data were store and analyzed for windows statistical software (Statistica for Windows 7.0). Descriptive statistics were calculated for all experimental data. Kolmogorov-Smirnov test was used to test if data were normally distributed. Linear regression and Pearson product movement coefficient of correlation was used to determinate relationship between 2-mile run and VO_{2max} among military personal. Statistical significance was set at $p < 0.05$.

RESULTS

The Kolmogorov-Smirnov test has shown that the data were normally distributed. The difference in terms of the age of participants was extremely big, with range from 19.10 to 47.60 age. According to this fact, other variables have also shown the big difference between minimal and maximal values. This can be especially seen in the variable 2-mile run, where the minimal value was 11.21 minutes and maximal 27.23 minutes (Table I). In addition, the oxygen consumption which has been tested by direct method, has the lowest value of RVO_{2max} = 35.72 mL O_2/kg/min and the greatest RVO_{2max} = 71.14 mL O_2/kg/min. The average values for the heartbeat were similar for both, the 2-mile run test ($HR_{max\ 2\text{-}mile\ run}$ = 192.32 ± 9.66 bpm) and for the direct measurement of oxygen consumption (HR_{max}=191.89 ± 8.87 bpm).

Table II shows that there is statistically significant correlation between the 2-mile run test and maximal oxygen consumption on absolute level (r = -0.385; $p < 0.01$), as well as for the relative values (r = 0.639; $p < 0.01$). Besides this, the 2-mile run test shows correlation with body mass ($p < 0.01$), as well as with the age of participants (r = 0.230) (Table II). There was no significant correlation between body height and the 2-mile run test (r = 0.061; p = 0.21).

TABLE I. Basic Descriptive Parameters

	Mean ± SD	Minimum - Maximum
Age (Years)	29.10±5.59	19.10 - 47.60
HR rest (bpm)	73.22±10.04	46.00 - 100.00
Body height (cm)	179.44±6.62	160.50 - 201.60
Body mass (kg)	82.39±11.24	69.50 - 120.60
2-mile run (min)	16.36±2.50	11.21 - 27.23
2-mile run (s)	993.84±150.52	681.00 - 1643.00
$RVO_{2\ max}$ (mL O_2/kg/min)	50.29±7.05	35.72 - 71.14
$VO_{2\ max}$ (L O_2/min)	4.13±0.60	2.57 - 5.86
Speed max (km/h)	14.57±1.85	11.00 - 20.00
HR_{max} (bpm)	191.89±8.87	163.00 - 214.00
$HR_{max\ KF}$ (bpm)	192.03±2.07	185.18 - 195.73
$HR_{max\ 2\text{-}mile\ run}$ (bpm)	192.32±9.66	163.00 - 221.00

HR rest- heart rate at rest; VO_{2max} - maximal oxygen uptake; RVO_{2max} – relative oxygen uptake; Speed max - maximal running speed; HR_{max} - maximal heart rate achieved in the test

TABLE II. Correlation Between 2-mile Run and VO_{2max}

	Age	Body height	Body mass	$RVO_{2\ max}$	$VO2_{max}$	Speed max
2-mile run (s)	.2306	.0615	.2219	-.6394	-.3851	-.7931
p	0.000	0.214	0.000	0.000	0.000	0.000

VO_{2max} - maximal oxygen uptake; RVO_{2max} – relative oxygen uptake; Speed max - maximal running speed;

DISCUSSION

The primary purpose of the current study was to determine the validity of the 2-mile run test as the predictor for the assessment of maximum oxygen consumption of soldiers. The result has confirmed our hypothesis that there is a positive correlation between laboratory determination of maximal oxygen uptake and field 2-mile run test of sufficient duration to allow energy production to occur primarily through aerobic pathway. Our study showed similar results in comparison to other studies[13,14,16,19] that dealt with relationship between maximal oxygen uptake and indirect assessment of VO_{2max}.

The level of aerobic fitness of soldiers plays a vital role in deciding one's ability to carry out duties required during emergency situations

or actual combat conditions. A test is required to easily and accurately assess the aerobic fitness of soldiers frequently, without imposing a health risk on the individuals tested. The most important indicator of physiological fitness that has positive correlation with cardiovascular health and total work output is maximal oxygen uptake[18,19].

The VO_{2max} values have quite large variations among general population, mostly arising of the natural endowment factors and the levels of physical activity. The average VO_{2max} per unit of body weight has been found to be remarkably constant in different groups once they are matched in physical activity habits. Many studies have been conducted to assess the VO_{2max} values in military personnel. The minimum requirement of aerobic capacity (VO_{2max}) for an US Air Force male between the ages 25 and 29 years and between 30 and 34 years to meet the Air Force fitness standards is 34 and 32 mL O_2/kg/min respectively[20]. Shvartz and Reibold[21] have stated that this results fall under the poor aerobic fitness category.

Ghosh et al.[13] have found negative linear correlation between the distance running performance and VO2max. The distance running performance was determined either from time taken to cover a certain distance or from distance covered within a certain time. In most of the studies, the participants had to run for more than 5-6 min at their maximum speed, which was determined by the ability to maintain a high steady state level of oxygen consumption. Although most researches have reported a higher VO_{2max} on treadmill than on bicycle ergometer (3.6 to 6.0% higher), bicycle ergometer is still being used[18]. Ghosh et al.[13] had reported a high correlation (r = -0.82) between VO_{2max} measured using bicycle ergometer and 2.4 km run timings[13] . The present study results also indicate that the time taken for 2-mile run test exhibited a negative correlation (r = -0.38) with VO_{2max}. However, the correlation was not as high as obtained with 2.4 km run.

Therefore, it can be concluded that 2-mile run test protocol is fairly accurate and valid to predict VO_2max values in male military participants. This field test is also applicable to great number of participants, taking into consideration the variability in age and beginning level of physical preparation for each soldier. This is an important fact since the participants in our study were remarkably heterogeneous group. Based on this, the test can be used for the selection in evaluation of aerobic endurance. It has clearly define scale, based on which could be easily determined the values of maximal oxygen consumption, no meter of age or level of conditioning of soldiers[22] . During this study, more than 400 soldiers were tested. Special emphasis was put on the practicality and sensibility in scoring procedure and implementation in military cause. However, further studies are needed in order to confirm the validity of tests for power, agility and coordination, and based on comprehensive test battery try to determine motoric abilities for each soldier. A good selection of tests will enable more quality candidates which would lead to a better combat preparation of whole unit. Formulating a battery of motor tests, criteria and physical fitness evaluations is a challenging and responsible task and it therefore needs to be constantly verified in practice, investigated and confirmed by scientific work methods. The study and periodical verification of an existing test battery applied in practice can thus serve as one of the forms of its evaluation. The process must also consider the changes brought about by global and local development trends. The best way for objective measuring cardiorespiratory endurance is to determine aerobic capacity or VO_{2max}. Treadmill or cycle ergometers are

required to properly determine VO_{2max} but this procedure is expensive and takes long time for only one participant. This study has demonstrated that maximal aerobic capacity can be accurately estimated from the results of two-mile run test.

There are a number of strengths to the current study, including a large study population of military recruits, topic actuality and useful for coaches, trainers and the uniformed military services. Besides that, there have been noticed specific study limitations. The study did not develop a simple prediction equation between observed variables. Also, the study did not evaluate the use of critical velocity and isoperformance curves. Despite results have shown significant correlations, the values are not high for some variables. The authors want to emphasis that big sample size used might contribute to obtain significant values in the correlation.

Using something that other armies employ or have already been tested, looks sometimes like the easiest and best way. Geographical, socio-demographic and other characteristics must be also taken into consideration, as well as the differences between various cultures. In order to establish or verify the state of affairs, future studies must be conducted. By doing this, new questions will arise that will enable further critical understanding. In this way research becomes a sensible continuum.

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