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Analysis Differences of Vo2max between Direct and Indirect Measurement in Badminton, Bicycle Racing and Rowing

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ABSTRACT

One of determinant factors of an athlete's high achievement is a good physical condition. The cardiorespiratory endurance becomes one of the vital physical condition components in sport. The measurement of cardiorespiratory endurance for the aerobic capacity can be conducted by measuring the maximum oxygen consumption (VO2max). The measuring method of VO2max value can employ the direct and indirect measurement approaches. The purpose of this study was to analyze the VO2max through the direct and indirect measurement methods in badminton, rowing, and bicycle racing by considering the different mechanism of the dominant movement of each other. The method was a descriptive quantitative study with comparative approach. The sample of this study were West Java male athletes in rowing, badminton, and bicycle race involving 24 athletes. Each sport consisted of eight athletes as the samples. The anthropometrics profiles of the athletes include age 23.5 ± 2.6, height 174.8 ± 3.2, weight 63.4 ± 2.1 and body mass index 23.5 ± 3.7. According to the data analysis result of VO2max testing of badminton, rowing, and bicycle racing athletes, it concludes that there was a strong significant correlation in the measurement through direct and indirect measurement in badminton sport (r = 0.85), rowing sport (r = 0.82) and bicycle race (r = 0.78). The result of the correlation test result presents that theVO2max test conducted through direct and indirect measurement approach did not show a significant difference test result. Therefore, both parameters can be used in each of the sport.

1. Introduction

The measurement of maximal oxygen consumption (V O2max) is widely used for athletes and the general public as a measure of aerobic fitness. The method used to measure the VO2max value consists of direct testing method in laboratory and indirect testing method through the field test [1]. The measurement of VO2max through direct testing is conducted through progressive loads by analyzing the oxygen intake and carbon dioxide excretion with the integration of the pulse rate in each period of time during the test [2]. Meanwhile, in the measurement of VO2max through indirect testing, the variable is measured through the equation score approach based on the determined time or distance, such as 12 minutes of running, 3200 of the distance, and 20m of the shuttle run bleep test [3].

The main difference of indirect testing is that the test assumes the prediction method as the consideration of

calculation. The prediction is based on the heart rate as the result of movement, intensity, and volume of movement conducted in a period of time and fatigue index [4]. The test administered through a predictive approach is considering the assumption of a linear relationship between the heart rate or power output with oxygen consumption during physical activity [5]. The strengths of this method include the use of simple devices/tools, easy to be conducted, affordable, involving larger participants, and time efficient [6].

However, the level of trust of the indirect testing method is only 70% - 85% [7]. Meanwhile, the VO2max test through direct testing has some strengths, including a higher accuracy value, larger number of measurement analysis component indicators, and the maximum test result as the test is preceded by calibration for detecting temperature, humidity or the height above the sea level, and the installation of heart rate monitor [8]. However, the direct testing requires a high cost, skilled and competence human resources, a longer time for the process, and conducted in a limited laboratory [9].

In order to obtain more realistic results, the measurement of maximal oxygen uptake should be performed according to the characteristics of a specific sport. This means that athletes should be tested on the treadmill, cyclists on the ergometer testing bike and ergometer rowing. A number of research have compared the result of VO2max value gained from direct and indirect measurement in various types of sport. However, the comparative analysis of VO2max test in specific sports with different dominant movements and the use of ergometer test device that suits the movement characteristics conducted, such as in rowing and bicycle racing, is still scarce. In addition, by considering the difference of metabolism system, energy demands, and the limited data related to the athlete's physiology of various sports with different movement characteristics, this study was aimed at analyzing the VO2max measurement method through direct and indirect VO2max testing in badminton, rowing, and bicycle racing by considering the different dominant movement mechanisms of each specific sports.

2. Literature Review

In general, an athlete needs a good physical condition to gain a high achievement [10]. One of the physical condition components that plays a critical role in sport is cardiorespiratory endurance [11]. Cardiorespiratory endurance is the ability of the body to do the intense and continuous physical activities that involve a group of major muscles [12]. The measurement of cardio respiratory endurance for aerobic capacity can be conducted through measuring the maximum consumption of oxygen (VO2max). VO2max is a maximum number of oxygen consumption during an intense physical activity to finally arrive in a fatigue condition [3]. The benefits of owning a high VO2max value for an athlete include the longer time to reach fatigue condition and could give a good performance during the tournament [13]

The energy capacity of the human body is responsible for the efficient energy supply of the muscular system during training and competition [6]. Whole body VO2max typically reflects a heightened capacity for cellular oxygen utilization within a specific activity [5]. There are considerable number of tests developed in many years for measuring the maximum oxygen consumption. It is well known, direct measurement of VO2 maxis recognized as the best single index of aerobic fitness, but that way is not always possible due to both expensive and require sophisticated instrument and trained staffs [7]. The indirect field tests do not require special equipment or conditions, they are very simple to perform and it is possible to do the test in a larger number of subjects at one time. Although the indirect tests are not as precise as direct measures but still they are considered as acceptable predictors of VO2 max [14]. Indirect measurement of VO2max is mostly based on the linear relationship between heart rate and oxygen

uptake during submaximal resistance exercise, as well as in the Astrand Test [10].

3. Methods

3.1. Participants

The participants involved in this study were West Java male athletes of rowing, badminton, and bicycle racing. The samples include 24 athletes, 8 athletes in each sport. The anthropometrics characteristic profiles of the athletes included age 23.5 ± 2.6, height 174.8 ± 3.2, weight 63.4 ± 2.1 and body mass index 23.5 ± 3.7.

3.2. Materials

The method employed in this study was descriptive quantitative study with comparative approach. A comparative study is a study that compares the existence of one or more variables on two or more different samples or in the different time.

The instruments used in this study included:

1) Multi use silicone face masks VO2max testing that is easy to be used during testing session. This masker kit is made from silicon to minimize the air leak during the test.
2) Calibration Syringe COSMED 3L calibration.
3) Polar H6 Heart Rate Sensor as the digital heart rate sensor device.
4) Treadmill ergometer, rowing ergometer, and static bicycle.
5) Screen monitor, projector, and bleep test software application

3.3. Direct Measurement

Direct measurement The preliminary CPET was assessed using a Quark PFT Ergo (COSMED® Rome, Italy) system by way of real breath-by-breath exchange data analysis during graded exercise testing (GXT) performed to the point of voluntary cancellation due exhaustion. The primary parameter measured was VO2max expressed in milliliters per kilogram per minute (ml·kg-1·min-1). Gas analyzers for oxygen (O2) and carbon dioxide (CO2) were calibrated for every test with a specific gas concentration (O2 16.10 % and CO2 5.20 % and NO2 rest) according to the manufacturer's recommendation. Flow meter turbine calibration (3 L syringe) was performed on a test basis. The GXT protocol was comprised of three stages: inaction, exercise and recovery. The inaction stage lasted for 2 min to achieve a baseline HR. The exercise stage started at speed of 6 km·h-1 followed by speed rise of 1 km·h-1 every 2 min. The incline remained constant at 1%. When person had reached exhaustion and submits, the active recovery stage began lasting for 3 min at starting values. VO2max was determined by the following parameters: a respiratory quotient (RQ) ≥ 1.15 or a plateau of VO2 in spite of a load increase. Quark PFT Suite monitoring software (COSMED®, Rome, Italy) was used to display data numerically and graphically in real time. Fluctuations of breath-by-breath data were minimized using six breaths smoothing and 30 sec averaging.

3.4. Indirect Measurement

The protocol test for indirect testing uses 20-m multi-stage shuttle run test. This test involves continuous running between two lines 20m apart in time to recorded beeps. For this reason the test is also often called the 'beep' or 'bleep' test. The participants stand behind one of the lines facing the second line, and begin running when instructed by the recording. The speed at the start is quite slow. The subject continues running between the two lines, turning when signaled by the recorded beeps. After about one minute, a sound indicates an increase in speed, and the beeps

will be closer together. This continues each minute (level). If the line is reached before the beep sounds, the subject must wait until the beep sounds before continuing. If the line is not reached before the beep sounds, the subject is given a warning and must continue to run to the line, then turn and try to catch up with the pace within two more 'beeps'. The subject is given a warning the first time they fail to reach the line (within 2 meters), and eliminated after the second warning.

3.5. Procedure

The test protocol for the bicycle racing test through the direct testing was conducted by using bicycle ergometer (Ergoline GmbH, Ergoline, Germany). The test initial position of the work load was 50W followed by 25W escalation in every 2 minutes of travel time by maintaining the speed of pedal stroke in 60 – 80 rpm and conducted until the athlete reached the fatigue condition [15].

Furthermore, the protocol test for badminton sport measurement through direct testing used treadmill ergometer. The stage of test procedure was conducted on a treadmill with the initial speed 2.75 km/hour and 10% of slope angle. In each 3 minute interval, the slope angle increased 5% with the speed escalation 2.2 km/hour that was conducted until the athlete reached a fatigue condition (Test, Stickland, Petersen, & Bouffard, 2016; Myrna et al., 2005). The last, the test protocol for rowing sport was measured through direct testing by using the concept 2 rowing step test technique [18] .

3.6. Statistical Analysis

The data analysis process was conducted by using Statistical Product and Service Solution version 22.0 with Pearson Product Moment test. The test was used to find out the degree of correlation between 2 variables, with interval or ration scale, by converting the value into the correlation coefficient value ranged from -1, 0 to 1. The -1 value means that there is a perfect negative correlation, while 0 means no correlation, and 1 indicates a perfect positive correlation.

4. Results

The followings are the data analysis results of the mean of VO2max value (ml/kg/min) in badminton, rowing, and bicycle racing by using the direct and indirect testing.

Table 1. The mean of VO2max value (ml/kg/min) in badminton, rowing, and bicycle racing using direct and indirect measurement

Badminton		Rowing		Bicycle Racing	
Direct Test	*Indirect Test*	*Direct Test*	*Indirect Test*	*Direct Test*	*Indirect Test*
Mean ± SD		Mean ± SD		Mean ± SD	
47.7 ± 2.3	51.7 ± 3.6	47.2 ± 2.5	50.9 ± 2.9	62.6 ± 3.3	55.7 ± 3.8

Table 1 presents mean and standard deviation of the measurement result of VO2max value through direct testing from each sport, for instance badminton (46.7 ± 2.3), rowing (43.8 ± 2.5), and bicycle racing (62.6 ± 3.3). Furthermore, the mean and standard deviation of VO2max test through indirect testing from each sport were 51.7 ±

3.6 for badminton, 50.4 ± 2.9 for rowing, and 55.7 ± 3.8 for bicycle racing.

Table 2. The range of point of VO2max value (ml/kg/min) through direct and testing

	Type of Sport		
	Badminton	Rowing	Bicycle Racing
Direct testing (mean)	47.7	47.2	62.6
Indirect testing (mean)	51.3	50.9	55.7
Range of point	3.6	3.7	6.9

From the two VO2max parameters, by using direct and indirect testing, the result shows badminton and rowing sports gained lower VO2max means when the measurement was conducted through direct testing in comparison to the result of the indirect testing with the range of point 3.6 and 3.7 for each. Meanwhile, the mean and standard deviation of Vo2Max value through direct testing was 62.6 ± 3.3 and indirect testing was 55.7 ± 3.8 in bicycle racing. The result shows a higher result when the test was conducted through direct testing compared to indirect testing with 6.9 range points.

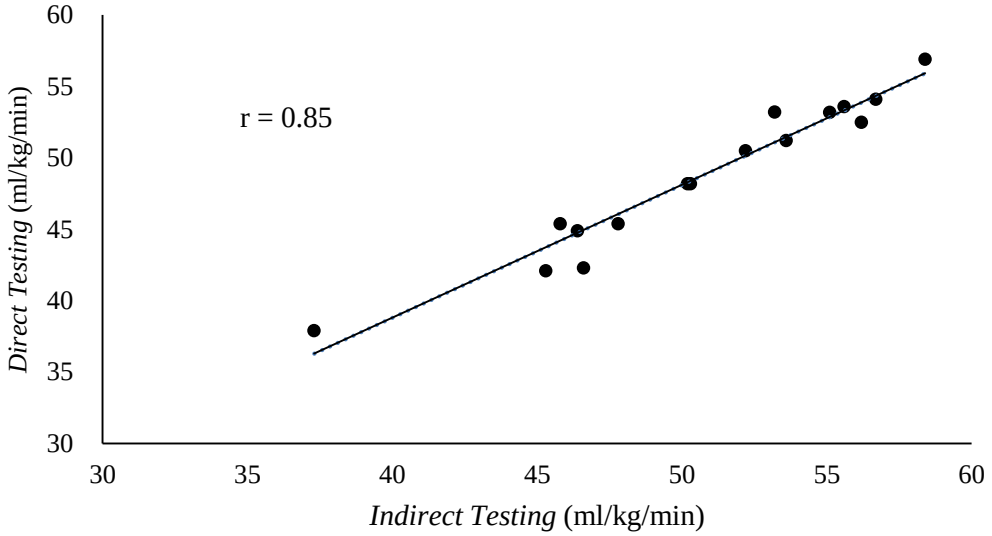

Figure 1. The correlation between the direct and indirect measurement in badminton

The data from Figure 1 describe that there is a significant correlation between the VO2max testing result by using direct testing approach and indirect testing approach in badminton sport (r = 0.85). The strong relationship indicates that the result of VO2max test conducted through direct testing is not significantly different with indirect testing result, which means that both of the test parameters could be used in badminton.

Figure 2. VO2max test through direct testing in badminton

One of the indicators of the results shows a significant similarity that the movement did during the indirect testing, using bleep test, through shuttle run with the increased rhythm and movement intensity that were not too different with the movement rhythm in badminton game [19].

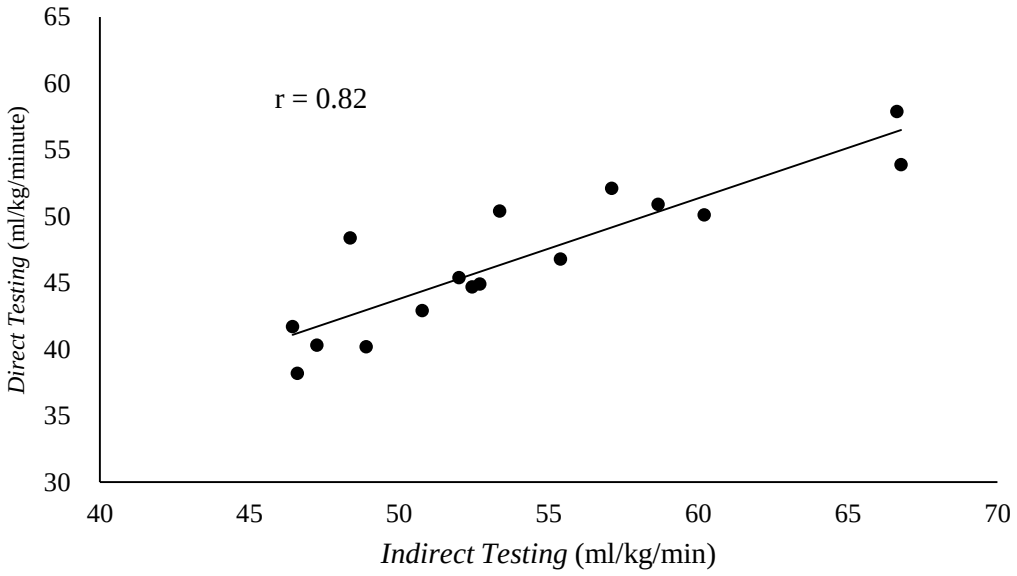

Figure 3. The correlation between direct and indirect measurement in rowing

The data shown in figure 3 present that there is a significant relationship between the result of VO2max test administered through direct testing approach and indirect testing approach in rowing (r = 0.82). The strong correlation indicates that the VO2max test result conducted through direct testing is not significantly different with the indirect testing. It concludes that both of the parameters could be used in rowing sport with the range of point 3.7.

Figure 4. VO2max test through direct testing in rowing

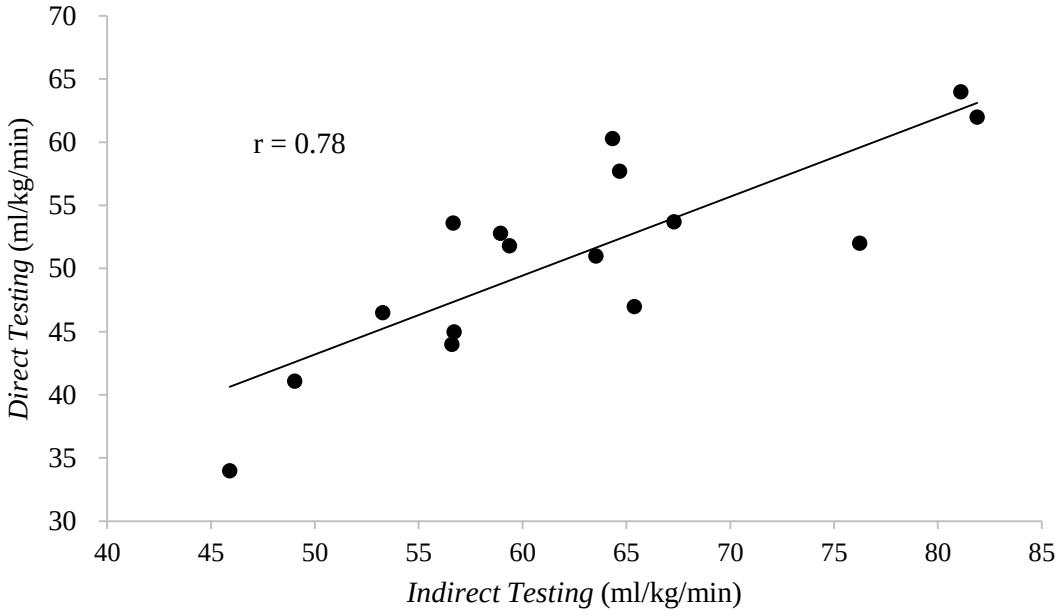

Figure 5. The correlation between direct and indirect measurement in bicycle racing

The data in Figure 5 depict that there is a significant correlation between the result of VO2max test by using the direct testing approach and indirect testing approach in bicycle racing sport (r = 0.78). The correlation result, with the moderate category, explains that the VO2max test result conducted by using the direct testing approach is not significantly different with indirect testing, thus both of the test parameters could be used in bicycle racing with the range of point 6.9.

Figure 6. VO2max test through direct testing in bicycle racing

However, the result of the Vo2Max test through direct testing (62.6 ± 3.3) and indirect testing (55.7 ± 3.8) in bicycle racing is different with rowing and badminton when the test was conducted through direct and indirect measurement with the range of point 6.9.

5. Discussion and Conclusion

The data obtained in the present study demonstrate that the two elaborated methods of estimation of maximal oxygen uptake yield more accurate results in direct and indirect measurement. This study was aimed at analyzing the VO2max measurement method through direct and indirect VO2max testing in badminton, rowing, and bicycle racing by considering the different dominant movement mechanisms of each specific sports.

The result of the Vo2Max test through direct testing (62.6) and indirect testing (55.7) in bicycle racing is different with rowing and badminton when the test was conducted through direct and indirect measurement with the range of point 6.9. It indicates that the characteristics of dominant movements of bicycle focus on the tilt of leg by using cycle ergometer supporting device. This finding is relevant with to research conducted by [18] that Vo2Max score of the bicycle racing athlete is higher when the test is conducted through a direct testing and its Vo2Max score is the highest among other types of sport.

The data analysis results of VO2max test on the badminton, rowing, and bicycle racing athletes conclude that, in the test through direct testing and indirect testing, there is a significant correlation with strong category in badminton (r = 0.85), rowing (r = 0.82), and bicycle racing (r = 0.78). The correlation result presents that the VO2max test result conducted through direct testing approach is not significantly different with the indirect testing approach result. Therefore, both of the parameters could be used in each type specific of the sports.

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