

# Measurement of Maximal Oxygen Uptake (VO<sub>2</sub>Max) as a Cardiorespiratory Physiological Fitness Parameter Using Sensor Technology-Based Device Development

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## Abstract

**Background:** This study aims to measure the maximal oxygen uptake (VO<sub>2</sub>Max) as a cardiorespiratory physiological fitness parameter using the development of a sensor technology-based tool.

**Methods:** This study uses a research and development design (Research And Development). Validation is carried out by competent experts. In this study, the researchers asked for validation from three experts, namely IT (electronics) experts, test and measurement experts and Sports Physiology experts (maximum oxygen volume). A total of 19 male and 11 female adults participated in this study. The usage trial was carried out using the expert validity method with an assessment using a questionnaire, test and retest. The data analysis technique used is r-correlation

**Result:** Based on expert validation tests, the reliability, practicality, and effectiveness of the development of test instruments based on sensor technology can be used to measure VO<sub>2</sub>Max and provide accurate and effective results.

**Conclusion:** The development of a test instrument based on sensor technology can provide accurate and effective results for measuring maximal oxygen uptake (VO<sub>2</sub>Max) as a cardiorespiratory physiological fitness parameter. This tool provides advances for monitoring VO<sub>2</sub>Max routinely in daily life, especially for carrying out training programs for athletes without the need for trained personnel and special equipment and expensive costs.

**Keyword:** VO<sub>2</sub>Max, Cardiorespiratory, Sensor Technology

## Introduction

Maximal oxygen uptake (VO<sub>2</sub>Max) is very important in delivering O<sub>2</sub> to muscles during sustained physical exercise which is considered a

standard of cardiorespiratory physiological fitness and is also a health parameter<sup>1,2</sup>. In addition, cardiorespiratory fitness is known to correlate with physiological factors such as body composition and blood pressure, as well as psychological factors such as depression<sup>3</sup>. High VO<sub>2</sub>Max is inversely proportional to the risk of cardiovascular disease and even death which reaches 17 million people worldwide<sup>4,5</sup>.

The most commonly used VO<sub>2</sub>Max measurement instrument with incremental running tests on a treadmill

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or other equipment such as a cycle ergometer<sup>6,7</sup>. In conducting measurement tests, most of the trainers complained about the difficulty of measuring VO<sub>2</sub>Max because it requires trained personnel and special equipment as well as expensive costs which may not be practical to repeat measurement tests to monitor Vo<sub>2</sub>Max on a regular basis so it is very difficult to implement in the Training program.

Alternative solutions need to be sought to overcome these problems. Recently, sports devices combined with sensor technology have gained benefits as an effective tool for assessing physical activity in the general population<sup>8</sup>. This is driven by advances in technology and lower costs. Sensor technology is widely used to measure heart rate and measure temperature that is inserted into personal devices such as smartphones and digital watches<sup>3,8-11</sup>. However, until now the effectiveness of sensor technology has not been tested to measure VO<sub>2</sub>Max in the fields of sports and health.

To answer this question, it is necessary to directly measure the maximal oxygen uptake (VO<sub>2</sub>Max) as a cardiorespiratory physiological fitness parameter

using the development of sensor technology-based tools.

## Methods and Materials

This study uses a research and development design (Research And Development). Called research-based development. After the product design is made, then ask for validation from a competent expert. Validation is carried out by competent experts aiming to find out the weaknesses and strengths of the product. In this study, the researcher asked for validation from three experts, namely: (1) IT (electronics) expert, (2) test and measurement expert (3) Sports Physiologist (maximum oxygen volume). Then the resulting product was tested for use in the field, as many as 19 men and 11 adult women participated in this study. The usage trial was carried out using the expert validity method with an assessment using a questionnaire, test and retest. The data analysis technique used is r-correlation.

## Result and Discussion

The results of the research used in this literature review are as follows:



Figure 1. Sensors and Data Storage LEDs Used in the Tool



**Figure 2. Results of the Development of VO2Max Measurement Tools Based on Sensor Technology Expert**

**Table 1. Questionnaire scores for the development of -based VO2Max measurement toolssensor technology by experts**

Expert	Aspect	Score	Relative Frequency
Media	Suitability	11	15%
	Accuracy	28	30%
	Conveniences	19	25%
	Practicality	26	30%
	Amount	84	100%
Test and Measurement	Suitability	12	35%
	Accuracy	20	25%
	Conveniences	18	25%
	Practicality	16	15%
	Amount	66	100%

**Cont... Table 1. Questionnaire scores for the development of -based VO2Max measurement toolssensor technology by experts**

Sports Physiology Material	Suitability	21	30%
	Accuracy	16	20%
	Conveniences	18	20%
	Practicality	22	30%
	Amount	77	100%

Expert Validity Test

**Table 2. Percentage and Eligibility Level of Experts**

Expert	Presentase	Eligibility Level
Media	84%	Very good
Test and Measurement	66%	Good
Sports Physiology Material	77%	Good

Based on the assessment by the three experts, the results of the development of the VO2Max test instrument based on sensor technology can be used to measure VO2Max.

**Reliability**

**Table 3. Descriptive Analysis of Reliability Test**

Day	n	Maximal Oxygen Uptake (VO2Max)		
		$\bar{x}\pm SD$	Minimum	Maximum
The First Day	30	30,49±5,17	23,60	45,50
The Second Day	30	32,65±4,56	27,20	45,50

Based on the results of the correlation coefficient of the reliability test, the tool developed as a VO2Max test instrument based on sensor technology is said to be reliable and consistent in retrieving VO2Max data.

## Practicality

**Table 5. Results of Practitioner's Percentage from Expert Assessment**

Expert	Percentage	Eligibility Level
Media	86,7%	Very good
Test and measurement	60,0%	Enough
Sports Physiology Material	73,3%	Good

Based on the results of the validation by the three experts, it was found that the tool developed by the VO2Max instrument based on sensor technology had a "Good" level of practicality.

## Effectiveness

**Table 6. Effectiveness Percentage Results from Expert Assessment**

Expert	Percentage	Eligibility Level
Media	73%	Enough
Test and measurement	72%	Enough
Sports Physiology Material	70%	Enough

Based on the results of the validity of the three experts, it was found that the tool developed by the VO2Max instrument based on sensor technology has an "Enough" level of effectiveness.

## Discussion

Cardiorespiratory physiological fitness level can be measured by estimation of VO2Max<sup>12</sup>. In this research, we use sensor technology based VO2Max instrument development to estimate VO2Max estimation.

In the validity test by media experts, it was found that the feasibility level was included in the very good category, validity test by test and measurement experts obtained a level of feasibility that is included in the good category, then the validity test by the exercise physiology material expert is included in the good category. The results of the correlation coefficient of the reliability test of the tool developed as a VO2Max test instrument based on sensor technology obtained results on the first and second

days with a high correlation so that it can be said to be reliable and consistent in retrieving VO2Max data. Based on the results of the validation by the three experts, the results of the development of a VO2Max measurement tool based on sensor technology have a level of practicality with a feasibility level included in the good category, and based on the results of the validation by the three experts, the results of the development of a VO2Max measurement tool based on sensor technology have a level of effectiveness with a feasibility level included in enough category. The results of the expert validity test prove that the development of a VO2Max test instrument based on sensor technology can be used to measure VO2Max. this is confirmed by research<sup>13</sup> that the optical heart rate (OHR) device in the form of sensor technology worn on the wrist can accurately estimate heart rate,

energy expenditure. In addition, research<sup>14</sup> reported that machine learning analyzes of sensors provided significant advances in the assessment of energy expenditure and aerobic fitness.

During aerobic exercise, VO<sub>2</sub>Max is very important to determine and track a person's cardiorespiratory physiological fitness<sup>14,15</sup>. The higher a person's VO<sub>2</sub>Max, the better the level of cardiorespiratory fitness, so it has the potential to increase performance in the world of sports<sup>16-18</sup>. The ability to predict VO<sub>2</sub>Max with the development of a test instrument based on sensor technology has the potential to provide an opportunity to obtain valuable information about cardiorespiratory fitness more effectively. The finding in this study is that the development of sensor technology-based test instruments can be used routinely in everyday life, especially to undergo training programs for athletes without the need for trained officers and special equipment and expensive costs. Therefore, the development of sensor technology-based test instruments can be used in the future to measure the level of cardiorespiratory fitness.

### Conclusion

The development of a test instrument based on sensor technology can provide accurate and effective results for the measurement of maximal oxygen uptake (VO<sub>2</sub>Max) as a cardiorespiratory physiological fitness parameter. This new technology provides advances for monitoring VO<sub>2</sub>Max routinely in everyday life, especially for carrying out training programs for athletes without the need for trained personnel and special equipment and expensive costs.

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