Prediction Model for Health-Related Fitness Status Using Discriminant Analysis

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ABSTRACT
Physical fitness represents the well-being of an individual and figures in measuring individual daily activities. This research aims to differentiate the physiological variables in distinguishing man fitness status without physical tests. The subjects of the examination amounted to 60 men aged 17-23 years old. The physiological parameters were age, weight, height, resting heart rate, blood glucose level, blood pressure, and VO2max, a bio-motoric component, measured by cooper protocol, running for 2.4 km. Subsequently, seven physiological and bio-motoric segments were analyzed using discriminant analysis. The result showed that resting heart rate and weight are strongly correlated with individual fitness. Discriminant analysis applying a stepwise method demonstrated that resting heart rate and weight were included in the fitness component formula. Furthermore, discriminant analysis results prove that 59.57 (98.3%) discriminant formulas can distinguish male fitness status. Fitness is an essential indicator in monitoring health. Concerning this, it is imperative to increase public awareness to regularly monitor their health status by assessing fitness status without having to do a physical test.

Keywords: *Fitness status, Prediction variable, Discriminant analysis.*

1. INTRODUCTION

Today knowing physical status is essential because it describes the body's immune ability to defend itself from virus attacks [1]. Regular physical exercise of fewer than 60 minutes is crucial in stimulating immune enhancement [2]. Lack of physical activity is the leading cause of death [3]. WHO reports that around 3.2 million people die each year from lack of physical activity [4]. Physical exercise is currently the best treatment for people to survive the virus attack.

Physical activity is a body movement that results from skeletal muscle in which energy use is required [5]. Participation in sports could positively contribute to human physiology, cognition, and psychology [6]. Regular physical activity can improve the quality of life by considering the time and the intensity [7]. Irregular exercise patterns may cause trouble in metabolism and, eventually, fitness. This disturbance occurs due to the lack of exercising strength, balance, endurance, agility, mobility, and flexibility training [8].

Fitness monitoring becomes a crucial step to performing and maintaining physical fitness. A fitness test typically uses a running test as an instrument, coupled with considering some rigorous methods. However, this test calls for tools, devices, and protocols that are both varied and advanced [9]. Coaches, talent scouts, government, and sports-oriented society demand a simple but accurate and flexible measurement method that can be performed in a situation with many samples simultaneously [10].

VO2max increment is a way to assess a fitness body that, in the end, could affect health. Aerobic capacity or VO2max has long been deemed a health predictor of detrimental illness, such as cardiovascular disease and other lethal diseases [11]. VO2max are important indicators too for the prevalence of carotid atherosclerosis [12].

Additionally, this research is important because home isolation from COVID19 is reported to have led to a reduction in all levels of physical activity, an increase in daily sitting time by approximately 28%, and an increase in consumption patterns. unhealthy food [13]–[15]. Therefore, we need to monitor health indirectly at all times. Controlling body size and body shape by doing extra exercise benefits children in physical fitness and motor performance [16]. Monitoring, especially physical fitness monitoring, will become a common feature of many physical education courses [17]. Physical health monitoring is an important task that must be carried out continuously [18].

Current fitness tests using the physical examination are conducted using direct and indirect methods and apply an indicator of the limit of individual capability in maximizing oxygen for metabolism energy or widely recognized as VO2max. This test requires individuals to exercise physical activity beforehand for acquiring their fitness status.

2. METHODS

The subjects were 60 active men that in a week only perform two until three times physical exercises. The resting heart rate was counted using cardiac telemetry, weight was scaled using a bodyweight scale, height was measured using a stature meter, and blood pressures were measured using a mercury sphygmomanometer. The fitness test was carried out by following a copper test running for 2,4 Km. Data analysis in this research used SPSS 26, and normality tests were carried out beforehand to comprehend data distribution using one sample KS (Kolmogorov-Smirnov). Following this, discriminant analysis is used to obtain a fitness data predictor. Test of significance was conducted on discriminant analysis by using a chi-square test to identify fitness status. Linear Discriminant Analysis (LDA) is a simple and effective pattern classification technique, and it is also widely used for early disease detection using electronic medical record (EHR) data [19]. Written informed consent has been obtained. People with a history of heart disease, lung disease, smokers, and medications for chronic diseases were excluded from the study. All procedures followed are in line with the Helsinki Declaration as revised in 2013 [20].

3. RESULTS

Table 1. The characteristic of the subject

Characteristic of subject	n = 60	
	Min – Max	Mean ± SD
Age (year)	17.00 – 23.00	19.78 ± 1.35
Weight (kg)	44.70 – 70.00	58.70 ± 5.22
Height (cm)	159.00 – 180.00	166.95 ± 4.76
Resting Heart Rate (beat/minute)	51.00 – 91.00	64.83 ± 7.93
Glucose Blood Rate (mg/dl)	64.00 – 100.00	86.73 ± 8.98
Systole (mmHg)	100.00 – 125.00	115.92 ± 5.41
Diastole (mmHg)	60.00 – 80.00	69.50 ± 5.02

Note. n – sample size, SD – Standard Deviation

Table 1 reflects the average variable discriminator of the research subject characteristic, namely age 19.78±1.35 years, weight 58.70±5.22 kg, height 166.95±4.76 cm, resting health rate 64.83±7.93 beats per minute, blood glucose level 86.73±8.98 mg/dl, systole 115.92±5.41 mmHg, and diastole 69.50±5.02 mmHg.

Table 2. Normality test

	Age	Wg	Hg	RH	GB	Sys	Ds
KS	1.17	0.66	1.23	1.30	0.99	2.90	1.17
Sig.	0.12	0.77	0.09	0.06	0.27	0.00	0.12

Note. Weight – Wg, Height – Hg, Resting Heart rate – RH, Glucose Blood – GB, Systole – Sys, Diastole-Ds.

The normality test in table 2 illustrates that only age, weight, height, resting heart rate, and glucose blood rate was typically distributed because of $p > 0.05$. Consequently, these five data could be used in multivariate correlation and discriminant analysis.

Table 3. Statistical results of the correlation test

	VO_2max	
	r	p
Age	-0.50	0.00*
Resting heart rate	-0.72	0.00*
Height	0.04	0.37
Weight	0.25	0.02*
Glucose blood rate	0.15	0.11

Note. r – correlation coefficient, *p* – p_{value}, *indicates p<0.05

The subsequent data analysis was followed by a correlation test among free and bound variables. Table 3 demonstrates that age, resting heart age, and weight was significantly correlated with VO2max. Those three variables affected the value of the VO2max sample. Considering the solid and inverse correlation, the less the importance of those three obtained, the more the volume of VO2max reached.

Table 4. Coefficient of discriminant function

	Coefficient of function
Resting heart rate	0.205
Weight	-0.070
Constant	-9.182

The statistic measurement displayed in table 4 shows the coefficient that could be included in the discriminant function model 1.

D = -9.182 + (0.205 x resting heart rate) + (-0.070 x weight)

The discriminant model 1 will be used for gaining a discriminant score that functions in predicting an object classification into a fitness group in which a score that is less than 0.0000167 includes a fit group. In contrast, a group with a value of more than 0.00 is an unfit group.

Table 5. Statistical results of significance test

Wilks' Lambda	Chi-square	df	Sig.
0.352	59.575	2	0.000*

Note. df – degree of freedom, sig. – significant, *indicates p<0.05.

The level of significance estimated based on chi-square and transformed statistically in Table 5 shows that Wilks' Lambda was associated with discriminant function at 0.35. This number then was converted to be a chi-square with a degree of freedom was amounted to 2. The chi-square value was 59.575. In light of that, it is reasonable to refute H0 with an error rate p = 0.00 and assert that the discriminant function succeeded in discriminating fitness status.

Table 6. Classification Results

		code	Predicted Group Membership		n = 60
			fit	unfit	
Original	Count	Fit	29	0	29
		Unfit	1	30	31
	%	Fit	100.0	.0	100.0
		Unfit	3.2	96.8	100.0

Note. n – sample size

Table 6. Demonstrates that discriminant function succeeded in differentiating fitness status with the accuracy in grouping individuals was 98.3%. This table explains that from 60 samples following the physical test, 29 models were considered fit, and it was proven 100% using the discriminant formula, which also showed the

fitness status. On the other hand, from 31 samples that were categorized in the unfit group, only 96.8% can be predicted, or only 30 models classified unfit based on the physical test. Therefore, one sample was predicted wrong by the discriminant formula.

4. DISCUSSION

Physical activities, notably aerobic activities, are the most effective way for non-communicable diseases. Physical activity could increase HDL production in mature humans that have lower HDL. An increase in HDL is helpful for non-communicable disease patients, such as heart attack [21], [22].

Increased physical activity will affect one's fitness. An increase in fitness is significantly effective in helping someone to maximize their routines. Individuals are highly recommended to know their fitness status to prepare their daily activities well. Typically, to measure it, physical tests, including running, are required. This test calls for several tools, methods, and specific protocols. Still, until now, an accurate but straightforward fitness assessment method has not existed yet, particularly for the activity affected by weight [23].

One of the roles of exercise regulation is weight loss programs. Improving asthma control, quality of life, and psychosocial symptoms help to clarify potential mechanisms for improved lung function, airways, and inflammation systemic in obese patients with asthma [24].

The research found that two-body characteristics, resting heart rate, and weight, affect one's fitness. The health of adolescents could be seen by resting heart rate since this method is way more straightforward than physical tests [25]. Increased cardiopulmonary fitness can reduce arterial stiffness mainly through resting heart rate. High muscle strength may have a detrimental effect on arterial stiffness, partially offset by a lower resting heart rate [26].

Elevated resting heart rate is an independent cardiovascular risk factor [26]–[28] positively associated with arterial stiffness [29], [30]. High RHR may be due to overactive sympathetic nerves, which can directly increase arterial stiffness by increasing the cyclic mechanical shear stress on the arterial wall [31]. Regular exercise to improve CRF can lower RHR, which may be a way to reduce arterial stiffness [26], [32], [33]. In addition, when adaptation is positive to training, the indices of heart rate and post-exercise variability associated with the vagus nerve, post-exercise heart rate recovery, and heart rate acceleration are significantly increased, thereby improving performance [34].

These HRV analyses can provide researchers with direct information about the contribution of the parasympathetic nerve (and, by extension, inferred knowledge about the assistance of the sympathetic nerve) on the impact of rest and post-exercise HR modulation [34].

Resting heart rate has a significant and robust correlation with VO2max [35]. Aerobic training will provide a reasonably practical advantage on the decline of resting heart rate [36]. Moreover, another research showed that resting heart rate is the most reliable predictor of VO2max and the best way to determine cardiovascular fitness [37]. The non-exercise variables of age, body mass, and resting heart rate may significantly predict the endurance abilities of athletes (VO2 max) [38].

The correlation test shows that weight has a lower correlation and is significant with VO2max. It is in line with research that stated that there was a negative correlation between BMI and VO2max and the increase in body fat due to the decline of VO2max in younger people [25], [26]. An increasing BMI affects physical fitness and causes a decrease in VO2 max [41]. These results are supported by research that shows that overweight girls can significantly reduce physical self-efficacy and underperform [42]. Cardiorespiratory fitness (CRF) provides an advantage in mediating the risk of heart failure (HF) associated with BMI [43].

Any physical activity that improves cardiorespiratory health should enhance lean body mass and reduce fat mass [42] so that the ideal body weight will support increased fitness. This research shows that weight and resting heart rate were the most reliable predictor in predicting fitness. With the discriminant formula obtained, the equation of this statistical calculation could predict an individual accurately with a fit field test. 98.3% was justified fit through fitness formula calculation based on discriminant statistical results.

5. CONCLUSION

The measurement of fitness that has been carried out through physical tests is quite heavy. This test makes many people reluctant to assess his fitness. As a result, their fitness status is not monitored, and it can affect their health status. This study has shown a formula that can predict an individual's fitness status. Discriminant analysis can help in classifying fitness categories in ordinary men without a physical test. The results of this study provide positive information between resting pulse rate and fitness status, which are both products of regular and programmed physical activity. The indicators are resting heart rate and body weight. Researchers suggest that future studies include other fitness variables and involve more samples, not exclusively men.

AUTHORS' CONTRIBUTIONS

BAP: study conception, design, data collection, and statistical analysis; YSM: statistical analysis, data interpretation and drafting of the manuscript; HF: study conception and data collection; N: study conception and design. All authors have read and approved the final manuscript.

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