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Correlation of Vital Capacity to Fitness Level: Related to Health of Juvenile Soccer Athletes

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Abstract. The scope of this study aims to determine the correlation of vital capacity (VC) and cardiorespiratory fitness (CRF), which is a type of fitness related to the health of juvenile soccer athletes. The results showed that there was a positive and significant correlation between VC and CRF with regression equation of $\hat{Y} = 31.998+3.206X$ and correlation coefficient of rxy = 0.511. Therefore, percentage of the relationship was expressed through a determination coefficient of 26.1% so the remaining percentage was influenced by other determinations. In addition, it was found that some athletes have a low CRF in line with low VC. Therefore, further research is needed to undertake to ascertain underlying cause the low of VC and CRF, thereby this research can be used to evaluate and determine the ideal athletes according to their position and capacity.

1. Introduction

Soccer is one of the first world's most widely played sports performed by men and women, children and adults with varying skill levels and the players need technical, tactical and physical skills, physiological and mental areas to succeed [1, 2]. During a 90 minute game, one of the important physiological requirements of a soccer athlete is to show his/her health-related fitness, which is a cardiorespiratory fitness (CRF) [3]. It is due to the average distance of the players covered in soccer games is about 11 km and 4 km to the goalkeeper, but that it depends on the position of the athlete [2, 4]. In this article, the focus of this study exclusively is on the correlation of vital capacity (VC) and cardiorespiratory fitness (CRF) in juvenile soccer athletes. Although cardiorespiratory fitness is strongly associated with the respiratory and cardiovascular systems, further analysis needs to be done to reveal statistically that vital capacity is one of the determinants in maximal oxygen uptake (VO_2Max).

2. Literature Review

One of the methods used to analyze the maximum capacity of the lung is the vital capacity (VC), which includes the inspiratory reserve volume, tidal volume and expiratory reserve volume (approximately 4.6 L) [5]. There are several factors that determine the lung's vital capabilities including body surface area, weight, height or length of stem and chest circumference [6]. While the ability to achieve high oxygen consumption through an effective oxygen transfer system from the atmosphere to somewhere in muscle, of a person who doing exercise, is the capacity associated with cardiorespiratory as measured by measurement of maximal oxygen consumption (VO_2Max) [7]. The effect of the functional organs size, such as the lungs size (related to vital capacity), the diffusing surface size, the lung capillaries size, the vascular system size, the heart size, the maximum heart rate and the concentration of hemoglobin in the blood are the dimensional prerequisites for oxygen transport [8].

Table 1. Standard of Cardiorespiratory Fitness of Indonesian Athlete (mL/kg/min)

Category	Male	Female
Very High	> 56.8	> 49.5
High	49.4 - 56.8	43.6 - 49.5
Average	41.8 - 49.3	35.4 - 43.5
Low	31 - 41.7	29.9 - 35.3
Very Low	< 31	< 29.9

Source: Implementing Unit of National Athlete Program [9]

In general, junior soccer players have lower CRF levels (<60 mL/kg/min) than senior soccer players [2]. The difference is also seen in the gender that the vital capacity in men is greater than that in women, thus affecting cardiorespiratory fitness [10].

Vital capacity has a direct role in providing oxygen in the lungs where it also affects the heart-lung capability [11]. In addition, there are determinations as mentioned above that body mass index, body fat percentage [11], body surface area and anthropometry (weight and height) [12, 13] are the determinants of the relationships between vital capacity and cardiorespiratory fitness. The main function of oxygen that enters the lungs is for the oxidative process capacity of the muscles carried by erythrocyte haemoglobin and pumped by the heart to produce ATP (adenosine triphosphate) [7]. ATP is the result of a series of metabolic systems used as energy by humans, especially soccer athletes so that they are able to maintain and have good cardiorespiratory fitness (CRF).

3. Methodology

Reported results were obtained from tests and measurements of 15-20 years old soccer juvenile athletes in Tangerang-Indonesia, where the football club was in the third-grade amateur class (the lowest soccer competition under the age of 21 years). The men involved in the study were twenty-three players on this team selected through random sampling based on age, health condition and major players [14]. The research method used in this research is survey method with data analyzed through the use of correlation and regression techniques which collect data on both variable vital capacity and maximum aerobic capacity in the bivariate population [15]. Data were obtained through measurement of vital capacity using Spirometer [16] and cardiorespiratory fitness using Multistage Fitness Test (MFT) [17].

4. Results

The results (Table 2) show the description of data distribution on predictor and criterion variables. The maximum, minimum, mean, standard deviation, median and variance estimates are the representations of all measured subjects. The results showed that the range of VC (X) was between 1.70 to 3.90, the mean value of 2.835, the standard deviation of 0.548, and the median of 2.80. Meanwhile, the CRF range (Y) is between 34.70 to 47.10, the mean value of 41,087, the standard deviation of 3.44, and the median of 40.80.

Table 2. Data Representation

Variable Value	Vital Capacity (VC)	Cardiorespiratory Fitness (CRF)
Maximum	3.90	47.10
Minimum	1.70	34.70
Mean	2.835	41.087
Std. Deviation	0.548	3.440
Median	2.80	40.80
Variance	0.301	11.835

All assessments were intended to measure the relationship between predictor (independent) and criteria (dependent) variables. The analysis obtained through the cardiorespiratory fitness equation of vital capacity of $\hat{Y}$ = 31,998+3,206X. It means that the relationship between vital capacity and cardiorespiratory fitness can be known or estimated through the regression equation (Table 3).

Table 3. Coefficient Correlation and Regression

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	31.998	3.396		9.422	.000
	VC	3.206	1.177	.511	2.724	.013

a. Predictors: (Constant), VC

b. Dependent Variable: CRF

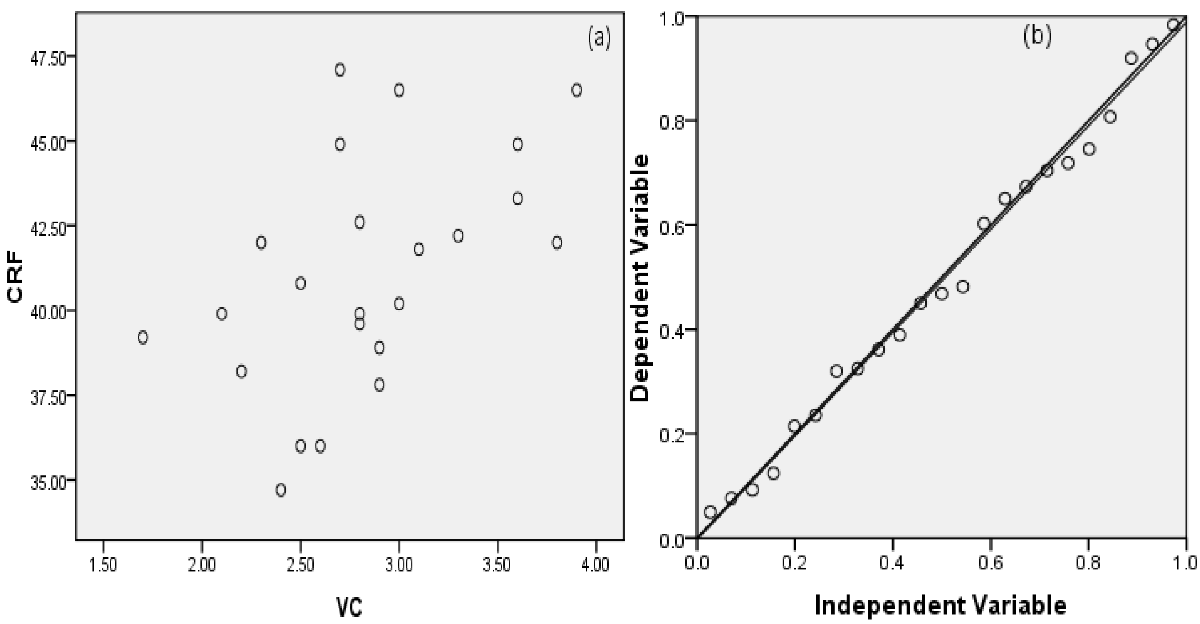

Fig. 1. Scatter Plot: (a) Deployment of Data and (b) Level of Relationship

Level of relationship (Table 3) between vital capacity (X) and cardiorespiratory fitness (Y) is shown by correlation coefficient $r_{xy} = 0.511$. The correlation coefficient should be tested for its significance before being used to make a conclusion. The significance result of correlation coefficient measurement is shown by t-count = 2.724 > t-table = 1.721. Therefore, H0 is rejected which means that the correlation coefficient of $r_{xy} = 0.511$ is significant and positive. The value of the relationship caused by the predictor variable to the criterion variable is shown by the determination coefficient of $(0.511)^2 \times 100\% = 26.1\%$. Therefore, the hypothesis stated that there is a significant and positive correlation between vital capacity of the lungs with cardiorespiratory fitness is accepted based on supporting research data [7]. It means (Fig. 1) that increased vital capacity (VC) of the lungs will also improve the cardiorespiratory fitness (CRF) [11].

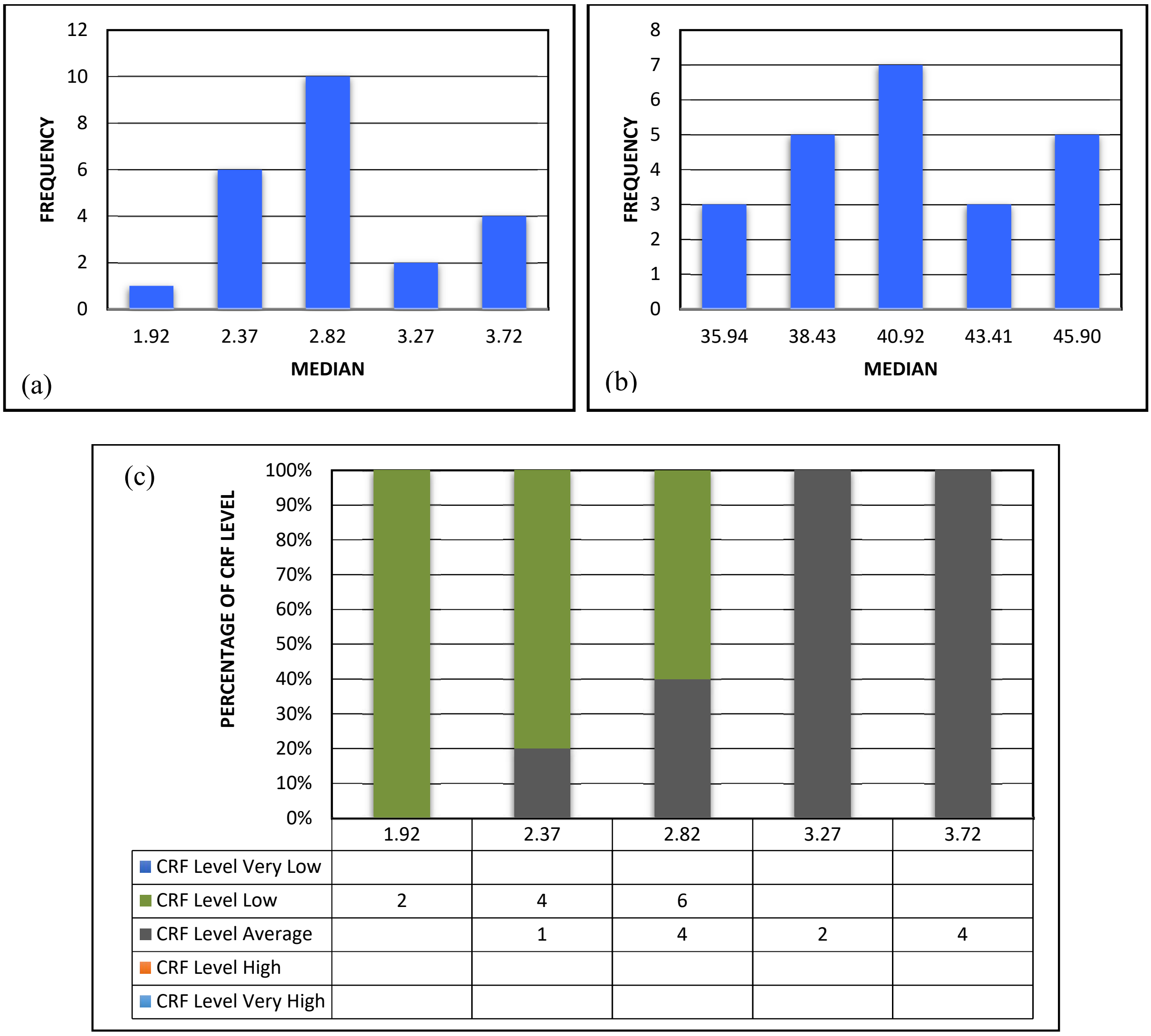

Fig. 2. Histogram of the (a) Frequency of VC, (b) Frequency of CRF and (c) Correlation of VC and CRF Scale

Based on figure 2 (a), compared to the sample number and average value, it is seen that the average number and percentage of samples in the class is 10 (43.48%) and below the mean class is 7 samples

(30.44%). Meanwhile, the sample above the average class is 6 samples (26.08%). Furthermore, in figure 2 (b) compared to the number of samples and average values, it is seen that the number and percentage of samples in the mean class is 7 (30.43%) and below the mean class is 8 samples (34.78%). While the sample above the mean class is 8 samples (34.78%).

Figure 2 (c) is a scale aims to identify and categorize the level of CRF in each median class of VC [18]. Based on the tables and histograms, samples in the middle class were 6 samples (60%) of low CRF levels and 4 samples (40%) of average CRF levels; the first lower class is 2 samples (100%) of low CRF level, and the second lower class is 4 samples (80%) of low CRF level, and 1 sample (20%) of the average CRF level (20%); and the two upper classes, both first and second, are 2 samples (100%) and 4 samples (100%) of the average CRF level.

5. Discussion

This is a study in several variables that correlate with cardiorespiratory fitness (CRF) that affects the functional ability of individuals, especially athletes. A number of researchers have examined the relationship between vital capacity and cardiorespiratory fitness through other determinations [6-8, 11-13]. Overall, a reasonable relationship occurs in these two variables due to each class corresponds to its classification through a low VC class with low CRF and high VC class with average CRF (Fig. 2c).

As exercise or physical activity increases, the oxygen requirement of the tidal volume also increases to 60% of the vital capacity so that it can increase the frequency of breathing [19]. While the condition of the vital capacity of the lungs when performing physical activity at least 5 minutes, a person needs about 3.5 L/min of oxygen [20]. Therefore, nearly half of the junior athletes in this team do not achieve the oxygen requirements per minute and the overall athlete lacks sufficient vital capacity so that it can affect the quality of cardiorespiratory fitness. The facts prove that in general the national teams from the continent of Asia, especially Southeast Asia, have CRF level lower than the elite national teams from continental Europe, such as Germany [2]. However, soccer has a variety of different physiological characteristics required by each player's position which can be utilized to cover physical deficiencies through tactics and techniques [21].

The highest performance of cardiorespiratory fitness is achieved at the age of 18 to 20 years and thereafter gradually decreases as the ageing process passes through routine exercise [20]. The sharp degradation in cardiorespiratory fitness will occur when a person is passively physically (sedentary lifestyle) within a certain period of time. Therefore, athletes who have reached their peak ages will attempt to maintain cardiorespiratory fitness in order not to decrease drastically. In addition, those who are under the peak period can be trained effectively to maximize and improve their cardiorespiratory fitness [22].

6. Conclusion

This study shows clearly that there is a positive and significant correlation between vital capacity and cardiorespiratory fitness by determination value of 26.1%, while other determinations are influenced by other variables, such as hemoglobin levels, the amount of blood pumped per ventricle per beat (stroke volume), the total amount of blood pumped by the heart per unit of time (cardiac output) and so on. Furthermore, these findings imply that the results obtained through tests and measurements on cardiorespiratory fitness levels of athletes are at a low and moderate level although the relationship of vital capacity and cardiorespiratory fitness is positive and significant. Therefore, further research is required by using determinant variables, such as anthropometry, exercise type, physiological characteristics and other performance attributes, so that will be obtained the cause of low vital capacity (VC) and cardiorespiratory fitness (CRF) of athletes. As a result, the soccer team will have the ideal players with right classification.

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References

[1] J. Hoff and J. Helgerud, "Endurance and Strength Training for Soccer Players", ***Sports Medicine***, Vol. 34, No. 3, pp. 165-180, 2004.

[2] T. Stølen, K. Chamari, C. Castagna and U. Wisløff, "Physiology of Soccer: Un Update", ***Sports Medicine***, Vol. 35, No. 6, pp. 501-536, 2005.

[3] P. B. Raven, L. R. Gettman, M. L. Pollock and K. H. Cooper, "A Physiological Evaluation of Professional Soccer Players", ***British Journal of Sports Medicine***, Vol. 10, No. 4, pp. 209-216, 2014.

[4] J. Bangsbo, "The Physiology of Soccer-with Special Reference to Intense Intermittent Exercise", ***Acta Physiologica Scandinavica. Supplementum***, Vol. 619, pp. 1-155, 1994.

[5] A. C. Guyton and J. E. Hall, “Pulmonary Ventilation” in ***Textbook of Medical Physiology 11th ed.***, Elsevier Saunders, PA/USA, 2006, pp. 471-482.

[6] T. K. Cureton, "Analysis of Vital Capacity as a Test of Condition for High School Boys", ***Research Quarterly. American Physical Education Association***, Vol. 7, No. 4, pp. 80-92, 1936.

[7] T. Reilly, N. Secher, P. Snell and C. Williams, “Marathon” in ***Physiology of Sports***, Spon Press, London/GB, 1990, pp. 107-134.

[7] T. Reilly, N. Secher, P. Snell and C. Williams, “Marathon” in ***Physiology of Sports***, Spon Press, London/GB, 1990, pp. 107-134.

[7] T. Reilly, N. Secher, P. Snell and C. Williams, “Rowing” in ***Physiology of Sports***, Spon Press, London/GB, 1990, pp. 228-254.

[8] A. Holmgren, "Cardiorespiratory Determinants of Cardiovascular Fitness", ***Canadian Medical Association Journal***, Vol. 96, No. 12, pp. 697-705, 1967.

[9] T. S. Prima, Standard Operational Procedure Tes Fisik Atlet, Program Indonesia Emas, JKT/IDN.

[10] E. E. McKay, R. W. Braund, R. J. Chalmers and C. S. Williams, "Physical Work Capacity and Lung Function in Competitive Swimmers", ***British Journal of Sports Medicine***, Vol. 17, No. 1, pp. 27-33, 1983.

[11] K. GÖRAL, "The Examination of The Relationship between Maximum Aerobic Power, Forced Vital Capacity and Body Composition in Soccer Players", ***Journal of Physical Education & Sports Science***, Vol. 8, No. 2, pp. 173-179, 2014.

[12] J. L. Mayhew and R. N. McKethan, "Further Analysis of Vital Capacity, Anthropometric Measurements and Endurance Performance", ***British Journal of Sports Medicine***, Vol. 7, No. 3-4, pp. 328-331, 2015.

[13] R. N. McKethan and J. L. Mayhew, "Relationship of Vital Capacity and Selected Anthropometric Variables to Two-Mile Run Time", ***British Journal of Sports Medicine***, Vol. 6, No. 2, pp. 47-49, 2015.

[14] C. Gratton and I. Jones, “Research Designs for Sport Studies” in ***Research Methods for Sport Studies***, Taylor & Francis, NY/USA, 2004, pp. 91-114.

[15] C. R. Kothari, “Processing and Analysis of Data” in ***Research Methodology: Methods and Techniques (Second Revised Edition)***, New Age International, DL/IND, 2004, pp. 122-151.

[16] J. Wanger, J. L. Clausen, A. Coates, O. F. Pedersen, V. Brusasco, F. Burgos, R. Casaburi, R. Crapo, P. Enright, C. P. M. van der Grinten, P. Gustafsson, J. Hankinson, R. Jensen, D. Johnson, N. MacIntyre, R. McKay, M. R. Miller, D. Navajas, R. Pellegrino and G. Viegi, "Standardisation of The Measurement of Lung Volumes", ***European Respiratory Journal***, Vol. 26, No. 3, pp. 511-522, 2005.

[17] L. A. Léger, D. Mercier, C. Gadoury and J. Lambert, "The Multistage 20 Metre Shuttle Run Test for Aerobic Fitness", ***Journal of Sports Sciences***, Vol. 6, No. 2, pp. 93-101, 1987.

[18] R. P. Duquia, J. L. Bastos, R. R. Bonamigo, D. A. González-Chica and J. Martínez-Mesa, "Presenting Data in Tables and Charts", ***Anais Brasileiros De Dermatologia***, Vol. 89, No. 2, pp. 280-285, 2014.

[19] R. J. Shephard and P. -O. Astrand, “Pulmonary System and Endurance Exercise” in ***Endurance in Sport***, Blackwell Science, London/UK, 1992 pp. 52-67.

[20] P.-O. Astrand and K. Rodhal, “Physical Performance” in ***Textbook of Work Physiology: Physiological Bases of Exercise 3rd ed.***, McGraw-Hill, NY/USA, 1986, pp. 295-353.

[20] P.-O. Astrand and K. Rodhal, “Physical Performance” in ***Textbook of Work Physiology: Physiological Bases of Exercise 3rd ed.***, McGraw-Hill, NY/USA, 1986, pp. 295-353.

[21] V. D. Salvo, R. Baron, H. Tschan, F. J. C. Montero, N. Bachl and F. Pigozzi, "Performance Characteristics According to Playing Position in Elite Soccer", ***International Journal of Sports Medicine***, Vol. 28, pp. 222-227, 2007.

[22] F. M. Impellizzeri, S. M. Marcora, C. Castagna, T. Reilly, A. Sassi, F. M. Iaia and E. Rampini, "Physiological and Performance Effects of Generic versus Specific Aerobic Training in Soccer Players", ***International Journal of Sports Medicine***, Vol. 27, pp. 483– 492, 2006.