available online at http://journal.uny.ac.id/index.php/jolahraga

Jurnal Keolahragaan, 10 (1), 2022, 110-117

Body fat levels and its negative correlation to apnea duration

Kukuh Pambuka Putra*, Rambu Lawu Nedi Kristanti Retno Triandhini, Aditya Wicaksana, Sanfia Tesabela Messakh

Fakultas Kedokteran & Ilmu Kesehatan, Universitas Kristen Satya Wacana Jl. Kartini 11A Kota Salatiga, 50711 Jawa Tengah

*Corresponding Author: kukuh.pambuka@outlook.com

Received: February 19, 2022; Accepted: April 11, 2022; Published: April 25, 2022.

Abstract: Apnea ability is the main determining factor of freediving performance. Apnea relates to physiological factors that might be experienced by a free diver hence its ability is highly likely to correlate with various factors of human physiology. One of the suspected factors that affect apnea duration is body fat level. The fact that fat is distributed in almost all parts of the body, including respiratory organs and tracts, arises the suspicion of a possible correlation between fat accumulation and apnea ability. This research studies the correlation between body fat level and apnea duration. 30 males, aged 18-22 were the research participant. Body fat levels were measured using Bioelectrical Impedance Analyzer, while apnea duration was measured by the length of which the participants hold their breath while sitting silently in the pool. The obtained data were then analyzed using a series of tests: normality, correlation, and linear regression tests. Pearson Correlation test shows negative result (p<0,05) with the value of correlation coefficient -0.611 which means negative correlation with medium strength. The result of the linear regression test also shows a similar value of 0.611. Meanwhile, the value of the determinant coefficient (R square) is 0.374 (37.4%). Based on the value obtained, it can be inferred that body fat levels have 37.4% influence on the duration of apnea, while the other 62.2% are influenced by a variety of other factors.

Keywords: apnea, body fat, freediving

How to Cite: Putra, K. P., Triandhini, R. L. N. K. R., Wicaksana, A., & Messakh, T. S. (2022). Body Fat Levels and its negative correlation to Apnea Duration. *Jurnal Keolahragaan, 10*(1), 110-117. doi: https://doi.org/10.21831/jk.v10i1.48131

INTRODUCTION

Diving is an underwater physical activity which is quite popular nowadays. Diving is done for various purposes. The most widely practiced is recreational diving. Diving can be done both without the use of equipment (free dive) or using a set of self-contained underwater breathing apparatus (SCUBA). Although free dive and SCUBA diving are both forms of diving activity, they both have different concepts and rules. Apart from the presence or absence of the use of breathing apparatus, one aspect that distinguishes free dive from SCUBA diving is the breathing technique. In free dive, before entering the water, the diver only relies on one deep breath and then holds his / her breath (apnea) throughout the dive (Seedhouse, 2011), while in SCUBA diving the diver carries a set of SCUBA breathing apparatus (Self-Contained Underwater Breathing Apparatus) which allows the diver to breathe throughout the activity.

Respiratory management is another difference between free dive and SCUBA diving. This impacted on diving duration and risks. In SCUBA diving, the diver can breathe longer, as long as the breathing apparatus capacity (Putra, Pratama, et al., 2020). Therefore, the dive will last relatively longer. SCUBA divers are not allowed to hold their breath during the dive and are not allowed to rise to the surface too quickly to avoid decompression sickness and Pneumothorax (Hall & Hall, 2021; Porcari et al., 2015). In free dive, the opposite applies. Free divers are not allowed to breathe during the dive, so they only rely on the limited quantity of oxygen trapped in the lungs and airways. Therefore, the dive cannot be done for a long time because the diver must immediately return to the surface to breathe before the oxygen in the lungs and airways runs out. If free divers do not immediately return to the surface when they run out of oxygen, then the diver has a high chance of experiencing a hypoxic blackout which can lead to drowning (Pearn et al., 2015). It is very dangerous for divers, but can be prevented with proper preparation and an understanding of one's own limits.

Due to the high risks of this activity, diving should only be carried out under certain conditions and with standardized equipment (Sukbar et al., 2016). In addition, diving activities are usually officially permitted if accompanied by a professional diver (divemaster or diving instructor), and all divers involved must have an open water diver license issued by an authorized institution. Safety planning and management should be highly considered prior to diving. Good planning and understanding of self-ability are very important to minimize the potential risks and to prevent possible accidents. On the other hand, in free dive, the understanding of self-ability the good planning on diving, especially in terms of the ability to hold their breath (apnea) is essential. Apnea ability may be the main determining variable in free diving today. The duration of apnea is sometimes used as a measure of the professionalism of a free diver.

There are 11 factors might potentially influence the apnea ability of a free diver, namely (1) diver's body composition (fat content, muscle mass, amount of body fluids, and so on), (2) hemoglobin and erythrocyte levels in the blood, (3) blood volume, (4) vital lung capacity, (5) oxygen absorption throughout the body (VO2max), (6) Resting Metabolic Rate, (7) heart rate, (8) oxygen saturation, (9) nutritional status, (10) psychophysical relaxation, and (11) environmental conditions (Fernández et al., 2017). The physiological component most often considered by free divers and often become the main assumption in regards to apnea performance is the vital lung capacity (Marongiu et al., 2015). Vital lung capacity is known to be positively correlated with apnea ability (Schagatay et al., 2007). Therefore, the greater the lung capacity is, the longer a diver can dive. The greater vital capacity of the lungs allows the availability of more oxygen in the lungs and airways (Putra, Pratama, et al., 2020). In addition to vital lung capacity, the body's ability to absorb oxygen (VO2max) which represents an indicator of fitness is also known to have a correlation with apnea ability. Many argue that the higher the VO2max value (the fitter) the longer the apnea duration is. However, studies have shown that the higher the VO2max, the shorter the duration of apnea. This is highly possible because when the VO2max value is higher, the oxygen absorption per minute will also increase which means the body is wasting its oxygen and its reserves will run out (Putra, Karwur, et al., 2020).

Body composition and apnea ability is also potentially related. The body is composed of various chemical elements starting from the smallest at the atomic, molecular, cell level, all of which make up a larger structure to the level of tissues and organs (Sherwood, 2013). To survive, all living tissues of the human body require and absorb oxygen all the time with varying quantities, tailored to individual needs (Shete et al., 2014). Currently, there are no studies that provide evidence for the relationship between body composition and apnea ability, so further research still needs to be done. This study aims to determine the relationship between body fat level (which is one of the body composition variables) and the ability to hold breath in free divers. It is hoped that the results of this study can be a reference for free divers to consider an exercise program and diet management that is oriented towards setting optimal body composition for free diving.

METHOD

This is an observational analytical study that investigate the relation between body fat level and apnea duration. A stopwatch with units of seconds is used to measure apnea duration, while bioelectrical impedance analyzer (BIA) is used to get the percentage of body fat level. BIA is a non-invasive, pain-free method of measuring the body fat level. This method has been widely used and validated to be used in various age group such as children, teens, adult and elders (Houtkooper et al., 1996; Vasold et al., 2019). Muscle mass measurement result using BIA can also be compared with the result of such using MRI (Magnetic Resonance Imaging) (Oshima et al., 2010).

How to use BIA is to stand bare feet on a metal plate of a scale-like tool, with both hands holding another metal plate attached to a handle for a few moments. Omron Karada Scan HBF-375 is BIA that is used in this study. This device works in a similar principal as the one developed by Muthouwali and team, that measures the electrical current of the body. The electric current used in the Omron Karada Scan HBF-375 is 50kHz 500µA so that the subject does not feel electrical stimulation and is safe when used. In addition, the current is also still below the threshold for electric current in the human body of 1 to 5 mA (Muthouwali et al., 2017). Omron Karada Scan HBF-375 only produces 50kHz 500µA electrical current hence it is safe to be used (Vasold et al., 2019) and the subject will not experience and electric stimulation. In addition, the current is also still below the threshold for electric current in the human body of 1 to 5 mA (Muthouwali et al., 2017).

This study involves 30 participants that match the inclusive criteria of: male, age 18 to 22 years old, height 160 to 170 cm, in good health, no phobia of swimming pool, no history of cardio respiratory disease and willing to be the subject of this study as proven by the signing of informed consent form. The exclusion criteria in this study were having a phobia of pool depths, being in a sick condition or in the process of being treated and not agreeing to be a subject in this study. This research has passed the ethical clearance test based on the ethical feasibility certificate number 120/KOMISIETIK/EC/9/2021 issued by Ethics Committee of Universitas Kristen Satya Wacana.

Apnea ability is measured by calculating how long a diver can hold the breath under water. While in the water, the subject was asked to sit still to minimize body movement and prevent the increase of heart rate that in turn might result in the increase of oxygen consumption. It can affect the result of apnea duration measurement. Apnea ability is measured after the subject took one deep breath and entered the water. This is done in a 1 meter-depth pool to avoid the risk of drowning and prevents panic. This measurement is carried out repeatedly for 3 times for each subject and the highest / largest result is used. A minimum of 3 seconds pause between each repetition is given to ensure the normality and stability of both respiratory and heart rate of the subject. Apnea duration measurement was performed using a stopwatch integrated into the Casio WS-2000H digital watch.

The data obtained were then tested using the Shapiro-Wilk method to determine the normality of the data distribution. The data is normally distributed if the p value > 0.05. Then to find out the relationship between body composition and apnea ability, the Pearson product moment correlation 1-tailed test was carried out. The data is said to have a correlation if the p value <0.05. To confirm the relationship between the two variables, a simple linear regression test was also carried out. Statistical analysis was performed using the IBM SPSS Statistics version 25 software.

RESULT AND DISCUSSSION

The summary results of the descriptive analysis are presented in table 1. The average body fat value is 18.68 ± 0.876% with a maximum value of 29.10% and a minimum value of 11.15%. The mean of apnea duration was 25.13 ± 1.87 seconds with a maximum value of 54.02 seconds and a minimum value of 9.42 seconds (Table 1). The results of the Normality Test with Shapiro-Wilk (Table 2) stated that the variables of apnea duration (p = 0.287) and fat level (p = 0.591), it is safe to say that the data for both variables are normally distributed (p > 0.05).

Table 1. Descriptive Statistic

	Mean	Maximum	Minimum
Body Fat (%)	18,68 ± 0,876	29,10	11,15
Apnea Duration (seconds)	25,13 ± 1,870	54,02	9,42

Table 2. Result: Normality Test (Shapiro-Wilk)

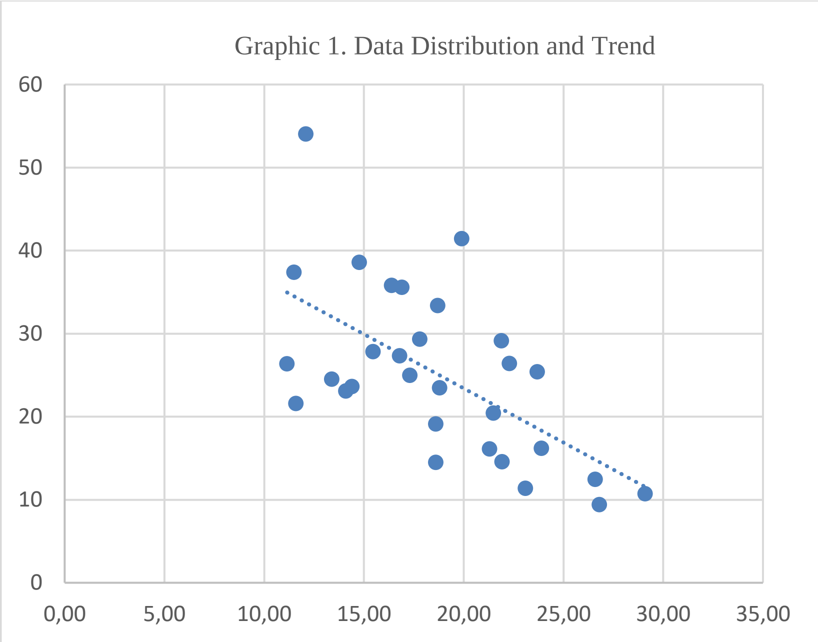
	Statistic	Df	Sig.
Body Fat (%)	0,972	30	0,591
Apnea Duration	0,959	30	0,287

Table 3. Result: Pearson Correlative Test

		Body Fat
Apnea Duration	Pearson Correlation	-0,611**
	Sig. (1-tailed)	0,000
	N	30

** Significant correlation on level 0,01 (1-tailed)

This study uses 1-tailed Pearson correlation test was performed to establish the correlation between body fat and apnea duration. The result indicated that there is such a relation (p<0,05). With the correlation coefficient value of -0.611, it means that the variables are negatively correlated with medium strength. This particular test resulted in the indication that the higher the body fat level is, the shorter apnea duration is. To confirm the relationship that occurs, a simple linear regression test was performed.



x: body fat (%), y: apnea duration (seconds)

Table 4. Result: Linear Regression Test

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig.
1	,611[a]	,374	,351	8,25004	,000

a. Predictors: (Constant), Body fat

The result of linear regression test is $p < 0.05$, therefore the model met the linearity criteria. In addition, the correlation coefficient value is 0.611 which means that the relationship between body fat and apnea duration is in the moderate category. Further, the value of 0.374 (37.4%) is obtained from coefficient of determination. It can be interpreted that body fat levels have 37.4% contribution of influencing the apnea duration, while the rest 62.6% were determined by other factors such as vital lung capacity and VO2max (Putra, Pratama, et al., 2020; Putra, Karwur, et al., 2020).

Excessive fat level might affect oxygen quantity in the body (Kapur et al., 2013). It is known that individuals with obesity experience reduction in components of lung capacity (Melo et al., 2014), hence the quantity of air is not as optimum as individuals with ideal body proportion. The reduction might be the result of unnecessary pressure (mechanical effect) in various parts such as respiratory tract, lung or diaphragm which is caused by the fat accumulation. The said fat deposits can also potentially cause several respiratory syndromes such as hypoventilation and asthma (Brock et al., 2020). In addition to fat deposits, it is suspected that blood fat level also contributes to the condition, especially in regards to cellular respiration and VO2max. Further research is needed to prove the suspicion.

Findings of previous study proved that vital lung capacity possess a strong positive correlation ($R = 0.743$) with apnea duration (Putra, Pratama, et al., 2020). Although the percentage is not suggested, the result of 1-tailed Pearson Correlation test managed to estimate the close relationship. As a result, it is highly likely that when lung capacity is interrupted, apnea duration will decrease, including the interruption caused by excess fat deposits.

During a dive, human body deals directly with the consequence of water physics (McArdle et al., 2009). The pressure increases as the depth is gained. The change of pressure is particularly experienced by the free divers who performed immersion dive, vertical dive to obtain certain depth; as opposed to dynamic dive that is performed horizontally in a rather shallow water. A prior study put forward an argument that there is a difference in hematology and cardiovascular response on free divers' apnea when performed on the water surface and during immersion dive (Schagatay et al., 2007). It is found that during immersion dive several things happened: spleen contraction, increase of hematocrit and hemoglobin, decrease of arteries oxygen saturation, increase of blood pressure, decrease of heart rate, peripheral vasoconstriction and increase of lactic acid (Marongiu et al., 2015; Ostrowski et al., 2012). Hematology and cardiovascular response might happen due to the change in environmental pressure, while the increase of lactic acid likely happened due to the anaerob metabolism (Kenney et al., 2015; Otto et al., 2013; Patel et al., 2017) that is caused by low oxygen level in the blood during apnea. It is highly suspected that hematology and cardiovascular response influenced the apnea ability of the free divers. Further research on the area is very potential due to the current limited existing research.

This study measures apnea in sitting still position. It is assumed that the higher the fat level is, the shorter apnea duration will be when the diver is in moving position, either in immersion or dynamic dive. According to a study by Roelofs, a swimmer's performance is not challenged by high body fat level (Roelofs et al., 2017). However, excessive body fat might cause a problem due to the magnitude of gravity in the water. Higher level of body fat also caused positive buoyancy which requires greater effort in a dive, especially in immersion diving. Greater effort needs greater energy for muscle contraction. In such condition, body metabolism will be faster, therefore, the body will consume more oxygen per minute resulted in the running out of oxygen reserves in the body. High oxygen consumption and also high VO2max will lead to the decrease of apnea duration (Putra, Karwur, et al., 2020).

The knowledge that body fat levels is negatively correlated to apnea duration should then bring awareness to the free divers to watch and maintain ideal body morphology. However, it is also important to keep the VO2max number low. Ideal body morphology is essentially ideal body composition (fat content and muscle mass) (Kim et al., 2019). In order to maintain proportional fat content and muscle mass, regular physical exercise and adequate diet is required. Sometimes, regular physical exercise will increase VO2max, for example High Intensity Interval Training (Putra et al., 2017). It is important to note that VO2max should be controlled since it might lessen apnea duration. Currently, there are no specific guidelines regarding physical exercise programs and proper diet management for free dive athletes in particular. Further studies need to be carried out to provide these guidelines to support the performance of the free dive athletes. Apnea is closely related to the rate of oxygen consumption and oxygen reserve capacity in the body. In principle, the more oxygen reserves in the body (both in the airways and dissolved in the blood), the longer apnea can be performed. So, the components related to the storage and distribution of oxygen in the body may need to be trained and optimized. The rate of oxygen consumption is related to the rate of oxygen distribution which is also influenced by heart rate, oxygen absorption which also depends on the intensity of muscle contraction at that time and how many cells absorb oxygen at one time. The more cells that absorb oxygen, and the greater the oxygen absorption capacity of a cell at a time, then the amount of oxygen reserves available in the body will decrease faster. In addition, the production and accumulation of carbon dioxide will also occur more quickly.

How the concept of proper physical exercise for free-diving athletes still needs to be studied more deeply. Many physical exercise models can generally increase the oxygen storage component (vital lung capacity, erythrocyte levels, hemoglobin levels, etc.) but usually also increase the body's oxygen uptake rate (VO2Max, mitochondrial count, muscle mass, and so on). This concept might also be considered for SCUBA diving. In SCUBA diving, it is also necessary to be able to conserve the breathing air carried by the diver. The goal is the same, to make diving lasts longer, especially in diving that has a specific professional purpose. The discovery of the right training model will be very beneficial for the diving world, especially freediving which is very dependent on the duration of the apnea ability.

Models of breathing and mind exercises such as yoga, pilates, meditation and tai-chi have the potential to be appropriate exercise models for free divers. In the model of these exercises much emphasis is placed on controlling the breath, concentration and mind, which can then produce calm and relaxation of the body. The diver's ability to concentrate and remain calm during a dive may also be important and can affect dive performance, so these exercises will have a positive impact if performed by a free diver. Further studies are needed in this regard. In the model of these exercises, muscles are also trained. Muscles are contracted but not with high intensity and/or contractions that are too strong, so the result may not increase the number of cells or the number of mitochondria. If so, then these exercises can be a potential reference for divers. Further studies are needed to prove it.

Although this study has attempted to prove a negative relationship between body fat levels and the duration of apnea, there are some limitations to this study that needs to be acknowledged. First, the measurement of fat content in this study could not distinguish between subcutaneous fat and visceral fat. Visceral fat has the potential to contribute more because of its location within the trunk and around organs. Better measurement methods and instruments are needed if similar studies are carried out in the future. Second, body fat level regarded in this study is the number of total body fat (Mulyawan, 2019). It is unknown yet whether fat levels per body segment have a different correlation or influence on apnea performance . Currently, there are many instruments that can measure body fat levels per segment, thus enabling further research to complement and refine this research.

It is also important to study the hematological variables, given that oxygen is distributed in the body through the blood (Capanema et al., 2022). Further research on other components of body composition such as muscle mass, bone mass, hematology and body fluids are highly recommended to be carried out simultaneously on the same subject. Based on the discussion written by the researcher, it appears that the potential for further research is still very broad.

CONCLUSION

Body fat level is negatively correlated with apnea duration, indicator of apnea ability in free-dive sports. However, body fat level does contribute to apnea performance of a free-diver. Therefore, it is essential for athletes of this particular sports to maintain body composition to optimize the performance, especially in competition setting.

REFERENCES

Brock, J. M., Billeter, A., Müller-Stich, B. P., & Herth, F. (2020). Obesity and the Lung: What We Know Today. *Respiration; International Review of Thoracic Diseases*, *99*(10), 856–866. https://doi.org/10.1159/000509735

Capanema, F. D., Lamounier, J. A., Ribeiro, J. G. L., Lima, C. O. V., de Almeida Paiva, A. R., Quadros, P. R., Ferreira, N. S. K., de Almeida, T. S., & Santos, N. C. M. (2022). Anemia and nutritional aspects in adolescent athletes: A cross-sectional study in a reference sport organization. *Revista Paulista de Pediatria*, *40*. https://doi.org/10.1590/1984-0462/2022/40/2020350

Fernández, F. D. A., González-Ravé, J. M., & Juárez, D. (2017). Breath-hold diving performance factors. *Journal of Human Sport and Exercise*, *12*(3). https://doi.org/10.14198/jhse.2017.123.03

Hall, J. E., & Hall, M. E. (2021). Guyton and Hall: Textbook of Medical Physiology 14th Edition. *Elsevier*.

Houtkooper, L. B., Lohman, T. G., Going, S. B., & Howell, W. H. (1996). Why bioelectrical impedance analysis should be used for estimating adiposity. *The American Journal of Clinical Nutrition*, *64*(3 Suppl). https://doi.org/10.1093/AJCN/64.3.436S

Kapur, V. K., Wilsdon, A. G., Au, D., Avdalovic, M., Enright, P., Fan, V. S., Hansel, N. N., Heckbert, S. R., Jiang, R., Krishnan, J. A., Mukamal, K., Yende, S., & Barr, R. G. (2013). Obesity is associated with a lower resting oxygen saturation in the ambulatory elderly: Results from the cardiovascular health study. *Respiratory Care*, *58*(5). https://doi.org/10.4187/respcare.02008

Kenney, W. L., Wilmore, J. H., & Costil, D. L. (2015). Physiology of Sport and Exercise. Sixth Edition. In *Human Kinetics*.

Kim, K. B., Kim, K., Kim, C., Kang, S. J., Kim, H. J., Yoon, S., & Shin, Y. A. (2019). Effects of exercise on the body composition and lipid profile of individuals with obesity: A systematic review and meta-analysis. *Journal of Obesity and Metabolic Syndrome*, *28*(4). https://doi.org/10.7570/JOMES.2019.28.4.278

Marongiu, E., Crisafulli, A., Ghiani, G., Olla, S., Roberto, S., Pinna, M., Pusceddu, M., Palazzolo, G., Sanna, I., Concu, A., & Tocco, F. (2015). Cardiovascular responses during free-diving in the sea.

International Journal of Sports Medicine, *36*(4), 297–301. https://doi.org/10.1055/S-0034-1389969/ID/R4051-0026

McArdle, W. D., Katch, V. L., & Katch, F. I. (2009). *Exercise Physiology: Nutrition, Energy, and Human Performance* (7th ed.). Lippincott Williams & Wilkins.

Melo, L. C. ost., Silva, M. A. layd. M. da, & Calles, A. C. arolin. do N. (2014). Obesity and lung function: a systematic review. In *Einstein (São Paulo, Brazil)* (Vol. 12, Issue 1). https://doi.org/10.1590/S1679-45082014RW2691

Mulyawan, R. (2019). Profil Antropometri Atlet Sepakbola Profesional Pada Masa Transisi. *MEDIKORA*. https://doi.org/10.21831/medikora.v18i1.29192

Muthouwali, A. N., Riyadi, M. A., & Prakoso, T. (2017). Rancang Bangun Alat Pengukur Persentase Lemak Tubuh Dengan Metode Whole Body Measurement Bioelectrical Impedance Analysis (Bia) Empat Elektroda Dengan Saklar Otomatis Berbasis Mikrokontroler ATMEGA 32. *Transmisi: Jurnal Ilmiah Teknik Elektro*, *19*(2), 50–57. https://ejournal.undip.ac.id/index.php/transmisi/article/view/15389

Oshima, Y., Shiga, T., Namba, H., & Kuno, S. (2010). Estimation of whole-body skeletal muscle mass by bioelectrical impedance analysis in the standing position. *Obesity Research & Clinical Practice*, *4*(1), e1. https://doi.org/10.1016/J.ORCP.2009.06.001

Ostrowski, A., Strzała, M., Stanula, A., Juszkiewicz, M., Pilch, W., & Maszczyk, A. (2012). The role of training in the development of adaptive mechanisms in freedivers. *Journal of Human Kinetics*, *32*(1), 197–210. https://doi.org/10.2478/v10078-012-0036-2

Otto, J. M., Montgomery, H. E., & Richards, T. (2013). Haemoglobin concentration and mass as determinants of exercise performance and of surgical outcome. *Extreme Physiology and Medicine*, *2*(1), 1–8. https://doi.org/10.1186/2046-7648-2-33

Patel, H., Alkhawam, H., Madanieh, R., Shah, N., Kosmas, C. E., & Vittorio, T. J. (2017). Aerobic vs anaerobic exercise training effects on the cardiovascular system. *World Journal of Cardiology*, *9*(2), 134. https://doi.org/10.4330/WJC.V9.I2.134

Pearn, J. H., Franklin, R. C., & Peden, A. E. (2015). Hypoxic Blackout: Diagnosis, Risks, and Prevention. *International Journal of Aquatic Research and Education*, *9*(3). https://doi.org/10.25035/ijare.09.03.09

Porcari, J. P., Bryant, C. X., & Comana, F. (2015). *Exercise Physiology (Foundations of Exercise Science) 1st Edition*.

Putra, K. P., Al Ardha, M. A., Kinasih, A., & Aji, R. S. (2017). Korelasi perubahan nilai VO2max, eritrosit, hemoglobin dan hematokrit setelah latihan high intensity interval training. *Jurnal Keolahragaan*, *5*(2). https://doi.org/10.21831/jk.v5i2.14875

Putra, K. P., Karwur, F. F., & Hidayati, N. W. (2020). VO2max Berkorelasi Negatif dengan Kemampuan Tahan Nafas (Apnea). *JOSSAE : Journal of Sport Science and Education*, *5*(2), 139. https://doi.org/10.26740/jossae.v5n2.p139-147

Putra, K. P., Pratama, R. P., & Nugroho, K. P. A. (2020). Kapasitas Vital Paru Berkorelasi Positif dengan Kemampuan Tahan Nafas pada Laki-Laki Usia 19-25 Tahun. *JOSSAE : Journal of Sport Science and Education*, *5*(1), 25. https://doi.org/10.26740/jossae.v5n1.p25-32

Roelofs, E. J., Smith-Ryan, A. E., Trexler, E. T., & Hirsch, K. R. (2017). Seasonal effects on body composition, muscle characteristics, and performance of collegiate swimmers and divers. *Journal of Athletic Training*, *52*(1). https://doi.org/10.4085/1062-6050-51.12.26

Schagatay, E., Andersson, J. P. A., & Nielsen, B. (2007). Hematological response and diving response during apnea and apnea with face immersion. *European Journal of Applied Physiology*, *101*(1), 125–132. https://doi.org/10.1007/S00421-007-0483-Y

Seedhouse, E. (2011). No Limits Freediving. In *Ocean Outpost*. https://doi.org/10.1007/978-1-4419-

6357-4_1

Sherwood, L. (2013). Introduction to Human Physiology,Edisi Internasional Lauralee Sherwood. *Human of Physiology*, *53*(9).

Shete, A. N., Bute, S. S., & Deshmukh, P. R. (2014). A study of VO2 max and body fat percentage in female athletes. *Journal of Clinical and Diagnostic Research*, *8*(12). https://doi.org/10.7860/JCDR/2014/10896.5329

Sukbar, S., Dupai, L., & Munandar, S. (2016). Hubungan Aktivitas Penyelam Dengan Kapasitas Vital Paru Pada Pekerja Nelayan Di Desa Torobulu Kecamatan Laeya Kabupaten Konawe Selatan Tahun 2016. *Jurnal Ilmiah Mahasiswa Kesehatan Masyarakat Unsyiah*, *1*(2), 186995.

Vasold, K. L., Parks, A. C., Phelan, D. M. L., Pontifex, M. B., & Pivarnik, J. M. (2019). *Reliability and Validity of Commercially Available Low-Cost Bioelectrical Impedance Analysis*. https://doi.org/10.1123/ijsnem.2018-0283