JOSSAE (Journal of Sport Science and Education)

OPEN ACCESS
E-ISSN Online: 2548-4699
http://journal.unesa.ac.id/index.php/jossae/index
http://dx.doi.org/10.26740/jossae.v8n1.p69-76

Comparison of VO_2Max Capacity and Lung Vital Capacity of Junior High School Students: Highlands and Lowlands

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Received: 7 May 2023 **Accepted**: 29 June 2023 **Published**: 30 June 2023

Abstract
Highland and lowland differences affect environmental adaptation to VO_2Max in athletes who train, so it is important to understand this in order to optimize training programs and achieve maximum performance. The purpose of this study was to determine the results of environmental adaptation for athletes who train in lowland highland areas to VO_2Max. This type of research is quantitative research with different types of tests or comparative tests. The population in this study amounted to 1356 male students. The sample in this study was 100 students using purposive sampling techniques. The hypothesis of this study is that there is a difference in VO_2Max capacity and lung vital capacity in highland students of Agam Regency with lowland students in Padang City, it can be seen from the posture of highland students having an average height of 163cm while the average lowland is 157cm, and body weight in the highlands has an average amount of 55kg while the lowlands are 51kg, and the body mass index in the highlands averaged 21.48 while in the lowlands it was 27.38. Based on the results of data processing, it was found 1) there was a significant difference between VO_2Max of junior high school students in highland areas and lowland areas p-value (2-tailed) of p=0.026 (<0.05). 2) There is a significant difference between the vital lung capacity of junior high school students in highland areas and lowland areas with p-value (2-tailed) of p=0.000 (<0.05) . It was concluded that VO_2Max capacity and lung vital capacity were better in junior high school students living in the highlands than living in the lowlands in large areas with an altitude of 542 meters above undersea level.

Keywords: Highland; lowland; lung vital capacity; VO_2Max.

1. Introduction

Physical fitness is a person's ability to do daily work efficiently without excessive fatigue so that they can still enjoy free time (García-Fernández et al., 2018; Goodyear, Kerner, & Quennerstedt, 2019; Utesch, Bardid, Büsch, & Strauss, 2019). Fitness can be classified into dynamic fitness, motor fitness, and static fitness groups. Health-related fitness has basic component, namely lung and heart endurance. Lung and heart endurance is the ability of the lungs and heart to supply oxygen for muscle work for a long time (Larsson & Karlefors, 2015; Opplert & Babault, 2018). Khodaverdi et al., (2016) stated that physical fitness is assessed by evaluating the heart's capacity to efficiently circulate oxygenated blood throughout the body and adapt during the post-physical activity recovery process. Physical fitness assessed by heart's pumping efficiency maximum ability of oxygen absorption, referred to in the term VO_2Max, which describes how efficiently the body utilizes oxygen during physical activity lasts from moderate to heavier degrees (Marisa, Yendrizal, Tohidin, Sujana, & Zarya, 2022; Ortega et al., 2015; Zarya & Welis, 2021).

A very important physical component in the development of children's achievement is cardiorespiratory fitness with a maximal oxygen volume level (VO_2Max) (Kusuma, 2019). VO_2Max is a

measure often used in aerobic fitness and shows the average maximal energy generated by an aerobic energy system (Wahyuni & Donie, 2020). VO_2Max is very important for physical performance and health in general because during heavy work a person's body needs twenty times the normal amount of oxygen (Indrayana & Yuliawan, 2019).

Physical growth is closely related to the occurrence of the process of increasing physiological maturity in each individual (Munir, Nasrulloh, Nyoman, Citra, & Kerihi, 2023). Growth and level of physical and physiological maturity have an impact on the development of physical abilities. In large children there is an increasingly clear development of physical abilities, especially in terms of strength, flexibility, balance, and coordination (Candra, Setiawan, Hermawan, & Sobihin, 2023). Sports coaching in children from an early age is very important because based on physical conditions and some characteristics in large children, environmental factors or residences such as those in the highlands or those in the lowlands affect the physiological and anatomical of children, this is The highland regions are predominantly characterized by plantations and forestry activities, resulting in cooler air temperatures in these areas. The local population, on average, engages in agricultural occupations, primarily working as farmers. While in lowland areas with areas that tend to be flat and the weather is hot. Lowlands are usually used for factories, industrial land, and more urban areas. The average lowland resident works as laborers, traders and farmers (Budiarso, 2006).

Based on the results of observations made by researchers that physical activity greatly affects student fitness, seeing from the fact that the difference in VO_2Max and lung vital capacity in children living in highlands and lowlands greatly affects physical growth. Basically, students who live in highland areas do more physical activity than students who are in the lowlands, the majority of students who live in the highlands help their parents in farming and students who go to school on foot. Unlike students who are in the lowlands, students do little physical activity because play time is very limited so that students spend more time in the room and playing games, and lowland school children go to school by private vehicle or public transportation. This is proven when research observes students who are in the lowlands and highlands when they do sports activities (Böning, 2019; Fan et al., 2021; Leonard, 2018). Physical activity carried out by children in highland areas is to prefer to do activities that are adventurous, such as doing river crawling while fishing, forest wandering by hunting using a catapult. While physical activities carried out by children in lowland areas are playing play stations, online games, cycling, fishing, doing games around the house (Lemoine, 2016; Rieger, 2022).

2. Method

The type of research used is observational research that uses experimental methods by comparing two different groups. The design of this study is using two groups pretest posttest design, where samples that have environmental conditions at high altitudes and samples that have environmental conditions at low altitudes using bleep test

This research was conducted in two places, namely in Agam Regency and Padang City, namely at SMP N 3 Mantur and MTS N 12 Agam in schools in the highlands and SMP N 15 Padang and MTS N 01 Padang in schools in the lowlands. The population is all male students aged 13-15 years numbering 1356 students. Samples are taken by cluster random sampling. On the grounds that the number of classes in each school is not the same. From some of these clusters, several samples were taken that were randomly selected or random. To limit the number of samples, the researchers pegged the sample at 25 students in each school, bringing the sample number to 100 students.

The type of data used in this study is primary data, data obtained directly from junior high school students in Agam Regency and junior high school students in Padang City. The data sources in this study are junior high school students in Padang City and Agam Regency, are: SMP N 03 Matur and

MTS N 12 Agam several junior high schools among them in Padang City include SMP N 15 Padang, MTS N 01 Padang.

Assessment instruments 1) vital lung capacity with these test tools and equipment consists of a rotary spirometer (water spirometer), a table or bench that is flat for the spirometer, cotton, alcohol, forms, data recording forms (Dwikuswono, 2010) Furthermore, to measure the VO_2Max capacity using the bleep test instrument.

Data analysis techniques

The research data is gathered and recorded in numerical format for analysis purposes data analysis used is statistical analysis. Independent Sample T-test was used to compare the difference in VO_2Max value and lung vital capacity between junior high school students living in the highlands of Agam Regency and those living in lowland areas in Padang City.

3. Result

Descriptive of VO_2Max value

Based on the results of VO_2Max measurements in children from highland areas, an average value of 38.98, a standard deviation of 6.8, a maximum value of 59.1 and a minimum value of 26.4 were found. For more details can be seen in the table below as follows:

Table 1. VO_2Max score frequency of students in the highlands

No	Classification	Frequency	Percentage (%)
1	Very Good	2	4%
2	Good	5	10%
3	Keep	12	24%
4	Less	13	26%
5	Less Than Once	18	36%
Sum		50	100%

Based on Table 1, it is known that VO_2Max scores with very good categories as many as 2 students with a percentage of 4%, good categories as many as 5 students with a percentage of 10%, medium category as many as 12 students with a percentage of 24%, less category as many as 13 students with a percentage of 26%, less category once as many as 18 students with a percentage of 36%. Based on the results of VO_2Max measurements on students from lowland areas, an average score of 25.97 was found, a standard deviation of 6.5, a maximum value of 51.1 and a minimum score of 23.2. For more details can be seen in the table below as follows:

Table 2. Frequency of VO_2Max scores of students in the lowlands

No	Classification	Frequency	Percentage (%)
1	Very Good	3	6%
2	Good	1	2%
3	Keep	11	22%
4	Less	4	8%
5	Less Than Once	31	62%
Sum		50	100%

Based on Table 2 it is known that VO_2Max scores with very good categories as many as 3 students with a percentage of 6%, good categories as many as 1 student with a percentage of 2%, medium categories as many as 11 students with a percentage of 22%, less categories as many as 4 students with a percentage of 8%, less once categories as many as 31 students with a percentage of 62%.

Descriptive of lung vital capacity value

Based on the results of measuring lung vital capacity in children from highland areas, an average value of 3124 was found, a standard deviation of 605.61, a maximum value of 4800 and a minimum value of 2000. For more details can be seen in the table below as follows:

Table 3. Frequency of student lung vital capacity scores

No	Classification	Plateau		Lowland	
		Frequency	Percentage (%)	Frequency	Percentage (%)
1	Very Good	14	28%	4	8%
2	Good	27	54%	10	20%
3	Keep	9	18%	31	62%
4	Less	0	0%	5	10%
5	Less Than Once	0	0%	0	0%
Sum		50	100%	50	100%

Based on table 3, it is known that the value of lung vital capacity with a very good category was 14 students with a percentage of 28%, the good category was 27 students with a percentage of 54%, the medium category was 9 students with a percentage of 18%, none of the students had less and less categories. Based on the results of measuring lung vital capacity in children from highland areas, an average value of 2230 was found, a standard deviation of 495.8, a maximum value of 3500 and a minimum value of 1300. Furthermore, the value of lung vital capacity with a very good category of 4 students with a percentage of 8%, good category as many as 10 students with a percentage of 20%, medium category as many as 31 students with a percentage of 62%, medium category as many as 5 students with a percentage of 10%, none of the students had a category of less than once.

Bivariate analysis

The hypothesis in this study was tested using t-test analysis. Before conducting a t-test analysis, a normality test is first carried out to find out whether the data is circulating normally or not. The normality test was performed by performing the Liliefors (Kolmogorov-Smirnov) normality test using the IBM SPSS 16 program. The assessment criteria is if $L_o < L_{tabel}$ = normal distributed data $L_o > L_{table}$ = data not normally distributed.

Table 4. VO_2Max normality test results

Variable		N	L_o	L_{table}	Conclusion
VO_2Max	Agam District Plateau	50	0,109	0,125	Normal
	Padang City Lowland		0,124	0,125	Normal

Based on table 4. It can be concluded that L_o for the variable lung vital capacity of highland students is = 0.115, the variable VO_2Max of lowland students is = 0.123, while L_{table} in the Lilliefors table with a significant testing level α= 0.05 with N = 50 obtained L_{table} of = 0.125. Since the Lilliefors (L_o) score of these two variables is small from L_{table} (0.125), it can be stated that the data of both variables with a normally distributed sample.

Table 5. Lung vital capacity normality test results

Variable		N	L_o	L_{table}	Conclusion
Lung Vital Capacity	Agam District Plateau	50	0,115	0,125	Normal
	Padang City Lowland		0,123	0,125	Normal

Based on table 5. It can be concluded that L_o for the variable lung vital capacity of highland students is = 0.115, the variable VO_2Max of lowland students is = 0.123, while L_{table} in the Lilliefors table with a significant testing level α = 0.05 with N = 50 obtained L_{table} of = 0.125. Since the Lilliefors (L_o) score of these two variables is small from L_{table} (0.125), it can be stated that the data of both variables with a normally distributed sample.

Table 6. VO_2Max difference test results

Variable		N	Mean	t_{count}	Sig. (2-tailed)	Information
VO_2 Max	Agam District Plateau	50	38,98	2.259	0.026	Significant
	Padang City Lowland	50	35,97			Differences

Based on table 6, it was found that the value of sig. (2-tailed) of 0.026 and for a significant value of 0.05 (5%). Based on these results, it can be concluded that there is a significant difference between VO_2Max junior high school students in the highlands of Agam Regency and those living in lowland areas in Padang City.

Test results of different lung capacity measurement

Another hypothesis for this study suggests that junior high school students residing in the highlands of Agam Regency exhibit varying Lung Vital Capacity and those living in lowland areas in Padang City. With the following basis for decision making:

Table 7. Test results of different lung vital capacity

Variable		N	Mean	t_{count}	Sig. (2-tailed)	Information
Lung Vital Capacity	Agam District Plateau	50	3124	8.077	0.000	Significant
	Padang City Lowland	50	2230			Differences

Based on table 7, it was found that the value of sig. (2-tailed) of 0.000 and for a significant value of 0.05 (5%). Based on these results, it can be concluded that there is a significant difference between the vital lung capacity of junior high school students in the highlands of Agam Regency and those living in lowland areas in Padang City.

4. Discussion

VO_2Max comparison of highland to lowland junior high school students

So this study is in accordance with research conducted by Sholikin (2012) which explains that there is a significant difference in VO_2Max levels between students of SMAN 16 Surabaya (lowland) and SMAN 1 Jogorogo (Plateau), where SMAN 1 Jogorogo is better. This study aims to determine the comparison of environmental adaptation for athletes who train at high altitudes and those who train at low altitudes to VO_2Max. Then it was found a significant disparity in VO_2Max was observed of athletes who trained in highland areas with lowlands in anaerobic exercise. Where VO_2Max levels of athletes who train at high altitudes are better.

VO_2Max represents the maximum oxygen uptake achievable during exercise. The VO_2Max value depends on the cardiovascular state, respiration, hematology, and oxidative ability of the muscles. VO_2Max is very necessary for sports activities, especially athletes, because VO_2Max is a picture of a person's endurance. Various factors influence an individual's VO_2Max, including temperature. Changes in temperature will indirectly affect VO_2Max, when the progesterone phase possesses a thermogenic impact, leading to an elevation in basal body temperature. This thermogenic effect influences cardiovascular function and, consequently, impacts VO_2Max.

Lowland is a plain that has a height that is almost the same as sea level, where in the lowland the temperature is hot, while the plateau is part of the earth's surface located at an altitude of more than 700 meters above sea level, which has a cool ambient temperature. Between the plateau and the lowland there is a difference in air pressure or O_2 pressure. Some phenomena or characteristics of people who are born and live in the highlands or mountains include: the chest size is larger, while the body size in highland residents, the size of their ventilation capacity slightly decreases, resulting in a larger ratio of ventilation capacity to body mass. Moreover, individuals living in highlands exhibit a significantly larger right heart, generating elevated pressure in the pulmonary artery, enabling efficient blood flow through the lung capillaries that have been greatly dilated. The transport of oxygen by blood to tissues is also much easier in people above or at high altitudes (Graha,2009).

Temperature is one of the factors that affect VO_2Max. In sports competitions there are often different temperature conditions between the training ground and the place of competition. For example, a soccer team is being prepared in a training center in a low-altitude area that tends to have high temperatures so that to start training, the body tends to heat up quickly and does not make it difficult for the breathing process. Meanwhile, when competing in highland areas that have low temperatures / temperatures which result in the body slow to heat, tend to stiffen, and difficulty breathing (Umar, 2014). Based on some of the factors and theories above, temperature and air or O_2 pressure can affect a person's VO_2Max, so the transport of oxygen by blood to tissues is also much easier in people at high altitudes than people at low altitudes.

Comparison of lung capacity among junior high school students residing in the highlands, a noteworthy distinction in vital lung capacity was identified with the lowlands

The structure of the human body around the world is different from one another. Factors such as genetics, race, gender, physical activity, nutrition are some of the things that can influence. The geographical conditions of human habitation can also affect the structure of the human body. Different geographical conditions of the earth in each region will provide different stimuli, for example, coastal areas and mountainous areas will give different stimuli to the body. In response, the body will make adaptations that affect the physiological state.

There are several factors that cause differences in a person's lung vital capacity, among others is air. Air exposed to dust, smoke and other air pollution will interfere with the work of the lungs. The longer a person is in an area that has polluted air, the vital capacity of one's lungs will decrease. In lowlands, especially urban areas, air quality is classified as labor, this is due to several factors including vehicle smoke, smoking habits, smoke produced by factories. The vital lung capacity of students living in higher mountainous areas compared to students living in low-lying areas can be caused due to environmental influences and student activities. Environmental factors concern the availability of oxygen. Low oxygen levels in mountainous areas increase lung ventilation, increased hemoglobin in the blood and increased vascularization of tissues. When exposed to low levels of oxygen (PO_2), the stimulation of chemoreceptors in response to hypoxia leads to a significant increase in alveolar ventilation, reaching a peak level of around 65 percent. Large lung volume for mountainous areas because it has undergone natural acclimatization.

Students living in mountainous areas have higher physical activity compared to students who are high in low-lying areas. Many students go to and from school on foot on the ascending and descending terrain which will help develop respiratory muscle strength. The lungs are one of the organs of the body that do not have their own muscles, so they are completely dependent on the surrounding muscles or depend on the development and sucking of the chest cavity (C. & J.E, 2007). In mountainous regions, characterized by plantations and forestry, the local climate tends to be cooler, and the majority of the population engages in occupations related to these industries farmers. While in lowland areas with areas that tend to be flat and in lowland areas that tend to be hot and many rice fields. Lowlands usually tend to be used for factories, industrial land, and are more inclined as urban areas so that areas in the lowlands are hotter. People in lowland areas make a living as laborers, shop assistants, merchants and farmers on average.

5. Conclusion and Recommendation

Based on the findings of the aforementioned study, the following conclusion can be drawn: 1) A significant discrepancy exists in the VO_2Max levels among junior high school students residing in the highlands of Agam Regency and those living in lowland areas in Padang City. VO_2Max students do better at high altitudes than at low altitudes. 2) There is a significant difference between the vital lung capacity concerning junior high school students in the highlands of Agam Regency, a notable difference in VO_2Max was observed and those living in lowland areas in Padang City. The vital lung capacity of highland students is better than that of lowland students.

Acknowledgement

Thanks to all ranks of samples and populations who have helped researchers, so that this research can be completed properly. So that this research can be useful for the surrounding community.

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