

The Differences in Adaptation Between Lowland and Highland Populations

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Manuscript received: 15 March 2023. Revision accepted: 18 April 2023.

Abstract. Indonesia is an archipelagic country with different characteristics of each island. Indonesian people face various challenges related to their geographical place of residence which can affect their body's adaptation. Apart from being influenced by race and ethnicity, habits and the outside environment greatly affect adaptation in humans. The three most striking areas that experience geographical differences in Indonesian territory are coastal communities, lowland communities and upland communities. Geographical conditions in fact provide differences in the special characteristics of each of its inhabitants. Not only related to physical development, but patterns of daily life can also be affected by differences in geographical conditions. Things that experience differences from the conditions of the population living in the highlands, lowlands and coastal areas include: The amount of hemoglobin in the blood, Food consumption patterns, Physical appearance such as height, skin color and chest shape, Prevalence of diabetes, Daily activity and work and Heart rate and lung capacity. The adaptation made by each resident in different types of geography is a necessity in order to be able to live without experiencing difficulties in carrying out daily activities. As for people in different geographies, they can still live with each other in different ages, but the general characteristics that exist will always be the same as places where they often carry out their daily activities.

Key words: adaptation, uoland, lowland, geographical

INTRODUCTION

Humans have different body structures and physiological functions among different races. The factors contributing to these differences, as stated in an article by Tambunan et al. (2016), include genetic factors, race, gender differences, nutrition, and physical activities. Additionally, geographical factors also influence the human body structure. Regions with different geographical conditions provide different stimuli to their inhabitants. This is supported by the opinion of Salipadang et al. (2022) that environmental factors, such as climate, temperature, weather, and altitude, can also affect human physiological processes.

In general, geographical differences in place of residence can be categorized as lowlands and highlands. Lowlands are defined as areas with an altitude of <200 meters above sea level (masl), while highlands have an altitude of ≥ 700 masl. The difference in altitude between these two regions brings about variations in the anatomical and physiological responses of individuals. Humans are capable of adapting to the geographical altitude differences in their place of residence. Organs such as the kidneys, heart, lungs, and hematological system are involved in this adaptation [3]. Some differences between these two regions

include differences in partial pressure of oxygen, atmospheric pressure, and temperature. Lowlands have higher air pressure compared to highlands, and the oxygen content is higher in lowlands than in highlands. These factors trigger the adaptation of the population inhabiting these two regions.

Habits carried out by the community in different environmental conditions are also influenced by the differences in location and challenges faced in those locations. Residents living in mountainous areas face the main challenge of cold temperatures. With such cold temperatures, special adaptations are required to ensure that the activities of the population are not limited, such as physiological changes involving increased hemoglobin. The increased hemoglobin in the mountainous population allows for optimal respiratory function even in the face of challenges caused by decreased oxygen levels in the air.

The challenges faced by residents in lowland areas, for example, include high air pressure due to gravity and dense air. Such physical conditions result in higher temperatures in low-lying regions. Coastal communities, in addition to facing challenges related to hot temperatures, also deal with higher salt content in the water compared to other areas. Understanding these various

characteristic differences is important in exploring the adaptations made by residents in each location. This paper will discuss the forms of adaptations performed and analyze them.

The differences experienced by the population in various types of regions can serve as a reference for providing adequate nutrition or government programs tailored to the needs of the community. Factors that can improve the health of the population can be adjusted based on the forms of adaptations they employ. Some important considerations in studying these adaptation differences include preventing diseases and addressing nutritional deficiencies. Coastal communities tend to consume a lot of salt but rarely have access to fresh vegetables due to unsuitable soil conditions for their growth. Conversely, communities living in mountainous areas consume more fruits and vegetables, which helps maintain their immune system.

People living in different geographical areas also require adjustments if they have to relocate. Even if the relocation is not for a long period of time, significant changes in location also lead to bodily adaptations that need to be quickly accommodated. The term acclimatization is often used to describe the process of adaptation for individuals who move to new environments. Proper adaptation can have an impact on subsequent

physiological functions, and failure to acclimatize may result in the failure of other physiological functions.

MATERIALS AND METHODS

This article is written using the qualitative literature review method by analyzing previous research articles searched on Google Scholar. The articles were analyzed, and their results were compared between the lowland and highland populations.

RESULTS AND DISCUSSION

Coastal Population Adaptation

Coastal populations experience unique characteristics related to their daily activities due to their location, which is situated at the border between land and sea. According to their geographical location, the livelihoods of coastal populations include fishing, tourism services, the fisheries sector, and coconut plantations. The coastal areas have a very hot temperature, with an average temperature of 27°C during the day. Coastal populations are exposed to more sunlight in their daily activities, leading to a specific change in the coastal community, namely, dark-colored skin.

In the consumption pattern of coastal communities, they consume a lot of protein

because the majority of them are fishermen. Coastal communities tend to have a higher pulse rate compared to other regions. This is related to the less optimal functioning of the heart.

Lowland and Highland Populations Adaptation

In an article written by Fernandez & Tirtayasa (2017) entitled "Changes in Mount Batur Climbers: A Description of University of Udayana Medical Faculty Students," it was found that there is a 76% increase in respiration when someone moves to highland areas. In addition, the body also shows various responses such as difficulty in breathing, fatigue, increased heart rate, cramps, nausea, tingling sensations, and even a feeling of fainting (Table 1).

The response felt by the respondents was a form of adaptation of their bodies which were originally in the lowlands and then given the highland conditions. This is the same as the research conducted by Salipadang et al (2022) entitled "Relationship

between Altitude Differences and Changes in Blood Pressure in Travelers from Lowlands to Highlands and from Highlands to Lowlands" provides an overview of human haematological adaptations when experiencing changes in altitude (Table 2).

This study shows changes in systolic and diastolic blood pressure in 50 respondents who traveled from lowlands to highlands and vice versa. Blood pressure increases proportionally with the altitude traveled and decreases when the respondents travel to lowlands. The body adapts due to changes in barometric pressure, and a decrease in barometric pressure reduces the partial pressure, which affects the respiratory process and leads to hypoxia. As a result, the body undergoes physiological responses known as acclimatization. Acute hypoxia increases heart rate, cardiac output, peripheral vasoconstriction, arterial blood pressure, and decreases oxygen saturation.

Table 1. Pattern of adaptation from lowlands to highlands.

Change	Frequency	Presentage
Increased Breathing Rate	20	15,7%
Feeling Faint During Climbing	2	1,6%

Difficulty in Breathing	18	14,2%
Feeling Weak and Tired Upon Reaching the Summit	23	18,1%
Chest Pain During Climbing	11	8,7%
Increased Heart Rate	22	17,3%
Cramps During Climbing	7	5,5%
Nausea or Discomfort in the Stomach During Climbing	10	7,9%
Headache During Climbing	7	5,5%
Tingling Sensations	7	5,5%
Total	127	100%

Table 2. Patterns of Blood Pressure Changes from Low to High Altitude

Paired Data Group	N (paired)	Correlation Coefficient	Hypothesis Test (asymptotic, sig-2 tailed, $\alpha = 0,05$)	Keterangan (significant if $p < 0,05$)
Systolic BP Manado- Tomohon	25	Pearson Product, $\rho = 0,897$	Paired T-Test, $p=0,000$	Hypothesis H1a accepted
Diastolic BP Manado- Tomohon	25	Kendall's Tau, $\tau = 0,779$	Paired Wilcoxon Test, $p= 0,048$	Hypothesis H1b accepted
Systolic BP Tomohon- Manado	25	Pearson Product, $\rho = 0,890$	Paired T-Test, $p=0,003$	Hypothesis H1a accepted

Diastolic BP Tomohon- Manado	25	Pearson Product, ρ =0,907	Paired T-Test, $p=0,024$	Hypothesis H1b accepted
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In the study conducted by Jufri et al. (2015) on "Differences in Blood Pressure in Children Living in the Mountains and Those Living on the Coast," the research was conducted at SD Inpres Wulurmaat, Modinding Subdistrict, South Minahasa Regency (mountains), and at SD Inpres 12/79 Wangurer, Madidir Subdistrict, Bitung City (coastline), resulting in the findings presented in tables 3 and 4.

Table 3. in boys

Region	Z	P
Systolic Mountains and Coastal Areas	-1,146	0,126
Diastolic Mountains and Coastal Areas	-1,055	0,146

This research shows that there is no significant difference in blood pressure among children residing in different geographical locations. However, different results were obtained from the study (Sukarno et al., 2014) titled "Comparison of Blood Pressure Between Residents Living in High Altitude and Low Altitude Areas". This

study was conducted on 80 individuals aged 18-65 years (Table 5).

Table 4. in girls

Region	Z	P
Systolic Mountains and Coastal Areas	-1,513	0,065
Diastolic Mountains and Coastal Areas	-1,084	0,139

Table 5 differences in blood pressure between lowland and highland areas

Diastole	Highland		Lowland	
	n	%	N	%
Optimal	26	32,5	7	8,75
Normal	31	38,75	20	25
High Normal	1	1,25	2	2,5
	72,5		36,25	

In this study, the results showed a significant comparison between the blood pressure of highland and lowland residents. The incidence of hypertension in lowland areas is higher than that in highland areas.

Additionally, a study conducted by Kasenda et al. (2014) titled "Comparison of Pulse Rate between Residents Living in Highland and Lowland Areas," which was also conducted in the same location, indicated that the pulse rate of lowland residents is higher than that of highland residents (Table 6).

Table 6. Differences in pulse rate between lowland and highland areas.

Location	Average pulse rate	Total pulse rate
Highland	69,84	5587
Lowland	91,6	7293

If we look back at both conducted studies, the lowland population has a more diverse eating pattern compared to the highland population. The sampled village of Malalayang is also located near the sea, resulting in a higher daily consumption of seafood among the lowland population compared to the highland population. This is supported by Teny et al's research (2019), which states that consuming salt will increase heart rate. Salt contains sodium, which, when it enters the bloodstream, retains water and increases blood volume.

The studies conducted on the influence of geographical differences on altitude variations indicate the existence of adaptation

processes carried out by the physiological system of the body in response to environmental differences. The research conducted by Fernandez & Tirtayasa (2017) and Salipadang et al (2022) show an increase in blood pressure when respondents move to highland areas and a decrease in blood pressure when respondents move to lower areas. The body also responds to altitude differences with symptoms such as nausea, headache, numbness, difficulty breathing, headache, increased breathing frequency, and a feeling of faintness.

On the other hand, the research conducted by Jufri, Kasenda, and Salipadang indicates that people in highland areas do not have higher heart rates or blood pressure compared to those in lowland areas. Instead, many people in lowland areas have high heart rates and blood pressure due to consuming salt, which is readily available in their surroundings. This lack of difference is a result of the homeostasis process, where the bodies of people in highland areas have fully adapted to their environment, thus eliminating negative feedback responses. This is consistent with the statement by Salipadang et al (2022) that there will be a decrease in blood pressure, a significant decrease in oxygen saturation, and a continuous increase in sympathetic nerves after spending several days in highland areas.

This gradual increase in nerves will eventually return the body to normal conditions (homeostasis).

From the research conducted by Hastuti et al. (2007), there are many morphological differences among humans living in lowlands and highlands, as observed from several body forms. In terms of body constitution, the chest circumference index provides more information about the subject's volume and musculature rather than respiratory capacity. The results show that the population in lowlands has a greater working capacity, leading to a more developed volume and musculature, resulting in a relatively larger chest size. The larger chest volume and rounded shape accommodate larger lungs, which is an anatomical adaptation of the highland population, resulting in a larger vital lung capacity. However, considering that males in lowlands have lower infrascapular skinfold thickness, this may need to be considered as a distinct condition. Typically, the lowland population has a larger chest circumference index. The distribution of chest index categories differs significantly between the two populations, both in males and females. The highland population, both males and females, has the highest frequency of flat chest index categories, except for the age group of 51-60 years, while the lowland

population, males and females of all age groups, has the highest frequency of average chest. It can be said that the lowland population has a more rounded chest cavity compared to the highland population. The enlargement of the chest cavity accompanied by increased vital lung capacity is an adaptive characteristic of the population residing in high-altitude areas, such as several populations in the Andes. Environmental and genetic factors are believed to influence the phenotype in those populations. In general, it appears that the lowland population tends to have narrower chest dimensions compared to the highland population. This observation is reasonable when considering the shorter stature of the lowland population compared to the highland population. It is likely that race and environmental factors play a significant role in these differences.

There are also differences in the average consumption of animal protein sources between the highland and lowland populations, with the highest recorded in the highlands at 77.5 grams/capita/day and the lowest in the lowlands at 51.49 grams/capita/day. This is because respondents in the highlands consume a more varied range of animal protein sources compared to the lowlands. Respondents in the highlands more frequently consume

animal protein sources from the sea, such as fish, shrimp, squid, and others, due to easy access to these food sources. On the other hand, respondents in the lowlands often consume plant-based protein sources from legumes, as their income levels are lower (Hamidah et al., 2017).

In this study, it has been proven that lowland areas are more prone to stunting compared to highland areas due to the occurrence of diarrhea, which is a risk factor for stunting in toddlers in lowland areas with a p-value of 0.01 and an odds ratio (OR) of 3.55, CI (95%): 1.29-9.80. These results indicate that toddlers who have experienced diarrhea in the last two months have a 3.55 times higher risk of stunting. This is influenced by environmental factors, especially the use of drinking water containing high salt levels and the scarcity of clean and safe water in the surrounding area, resulting in poor sanitation.

The level of physical fitness is also influenced by environmental factors, one of which is altitude. In a study conducted by Satriyono et al (2022), it is stated that the physical fitness of SMPN 1 Probolinggo, located in a lowland area with an altitude of 440 m, is better than that of SMPN 9 Malang, located in a highland area with an altitude of 10 mpdl. From these results, it can be said

that altitude will cause environmental differences that can affect health.

CONCLUSION

The geographical conditions actually provide distinct characteristics to each population. It is not only related to physical development but also influences daily life patterns due to the differences in geographical conditions. Some of the differences among populations living in flatlands, highlands, lowlands, and coastal areas include hemoglobin levels in the blood, dietary consumption patterns, physical characteristics such as height, skin color, and chest shape, prevalence of diabetes, daily activities and occupations dan heart rate and lung capacity

Adaptation by individuals in various geographical regions becomes a necessity in order to live without facing difficulties in carrying out daily activities. Despite the geographical differences, communities can still coexist in different geographies, but the common characteristics will always be the same as the place where they predominantly engage in daily activities.

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