Effects of High Altitude on the Cardiopulmonary Physiology of Young Adult Novice Hikers

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ABSTRACT

Hiking involves ascending trails of increasing elevation and altitude as the hike progresses. It has variable effects on a person's cardiopulmonary physiology depending on factors such as acclimatization and prior experience. This study investigated the effects of high-altitude hiking on the cardiopulmonary physiology of young adult novice hikers during their ascent of Mt. Pulag, Philippines. Eighteen healthy participants were monitored for changes in blood pressure, pulse rate, oxygen saturation, and Lake Louise Scores (LLS) across three altitude points: jump-off (2,475 m), Camp 1 (2,582 m), and Camp 2/Radio Tower (2,824 m). A significant increase in pulse rate was observed during the initial ascent, while blood pressure and oxygen saturation remained stable with insignificant changes. LLS remained low throughout the duration of the hike, indicating no observed cases of acute mountain sickness, likely due to overnight acclimatization at the jump-off point. Findings suggest that short-term high-altitude exposure is generally safe and tolerable for healthy novice hikers, causing only minor physiological adjustments with no observed cardiopulmonary distress. Evidence suggests that being provided nearly 24 hours of acclimatization at moderate to high altitudes prior to the hike is adequate for most healthy young adults despite being novice hikers.

Keywords: high altitude, hiking, acclimatization, physiology

INTRODUCTION

Hiking is an outdoor activity that is enjoyed by many enthusiasts, both young and old. It offers great accessibility and fosters a connection with nature. Not only does it encourage people to explore uncharted areas, but it also provides benefits from a wide array of health advantages (Smith et al., 2023).

Hiking has been perceived as generally beneficial to our body. It is often linked with the improvement of cardiovascular health, mental well-being, and physiological endurance. Hiking is celebrated for its therapeutic effects, including natural stress relief, mood enhancement, and improvement of cognitive function (Boere et al., 2023).

The popularity of hiking has grown significantly in recent years, especially during and after the COVID-19 pandemic.

More people sought safe and accessible alternatives to stay active, relieve stress, and reconnect with natural surroundings. Beyond its physical health benefits, hiking is considered a sustainable tourism practice supporting rural communities and promoting cultural tourism (Acevedo-Duque et al., 2022).

However, hiking is an adventure with varying degrees of risks. In high-altitude regions, hikers begin to encounter challenges related to decreased oxygen availability, a phenomenon known as altitude hypoxia, which brings physiological adaptations and symptoms such as dizziness (Bilo et al., 2019).

The effects of high altitude on human physiology are marked by a decrease in atmospheric pressure, which reduces oxygen concentration and leads to a condition called hypoxia. At altitudes above 1,500 m, the body must adapt to lower oxygen availability by increasing the heart and respiratory rates to maintain adequate delivery of oxygen to the vital organs (Marriott & Carlson, 1996). Regulated by the autonomic nervous system, this response ensures that oxygen is distributed to critical organs and tissues; however, prolonged exposure to hypoxia can place strain on the cardiovascular system and increase the risk of altitude-related illnesses such as acute mountain sickness (AMS), high-altitude cerebral edema (HACE), and high-altitude pulmonary edema (HAPE; Savioli et al., 2022).

In addition, hikers at high altitudes often experience altitude-related dizziness, shortness of breath, and other symptoms associated with hypoxia. These symptoms arise due to the decreased oxygen availability in the thin atmosphere, which impacts the body's ability to sustain efficient cellular respiration, leading to increased respiratory and cardiac demands (Bilo et al., 2019). Monitoring physiological parameters, such as blood pressure (BP), heart rate recovery (HRR), and oxygen saturation (SpO2), provides insight into the body's adaptive responses to hypoxic conditions. HRR, an indicator of the autonomic nervous system balance, typically decreases at high altitudes, reflecting a shift in sympathetic nervous system (SNS) activity to manage the acute stress response, which helps maintain BP and heart rate under reduced oxygen conditions (Bilo et al., 2019; Mallet et al., 2021).

SpO2, as measured using pulse oximeters, also declines with increased altitude, affecting the body's ability to perform physical activities (Mallet et al, 2021). Reduced SpO2 is directly linked to limited oxygen delivery to tissues which impair endurance, cognitive functions, and overall physical performance, especially for unacclimatized individuals such as novice hikers (Bilo et al., 2019). Consequently, tracking BP, HRR, and SpO2 levels can provide valuable information about altitude adaptation and individual resilience to hypoxic stress, helping hikers better prepare and mitigate high-risk environments.

Hiking at high altitudes offers a unique blend of challenges and rewards, balancing the physiological stresses of altitude hypoxia with the mental and physical health benefits of outdoor activity. Given its accessibility and therapeutic potential, hiking remains a vital recreational activity and a focal point for examining human adaptability in hypoxic environments.

This research aims to determine the effects of altitude on the cardiopulmonary physiology of young adult novice hikers during their climb of Mt. Pulag in Bokod, Benguet. This research specifically aims (1) to determine the sociodemographic characteristics and level of preparedness of young adult novice hikers participating in the study; (2) to monitor the BP, HRR, and SpO2 among the participants in response to increased altitude during hiking; (3) to determine the effect of increasing altitude on BP, HRR, and SpO2 levels; and (4) to observe and document any signs and symptoms of acute altitude sickness experienced by the participants.

METHODOLOGY

Research Design and Study Participants

This study is a descriptive cross-sectional study that involved young adult Filipinos aged between 18 and 34 years old who are lowland residents, are categorized as beginner to novice hikers, and have zero to five previous hiking trips (Kogut & Rodewald, 1994). All participants underwent a health screening and orientation to ensure physical readiness and informed consent before the high-altitude hike. The following individuals were excluded from the study: professional and veteran hikers and athletes and those with preexisting illnesses and chronic diseases due to their high risk of adverse effects when exposed to high altitudes (Furian et al., 2022; Mallet et al., 2021). meaning.

Study Setting

The study was conducted on Mount Pulag, Bokod, Benguet, with the highest peak in Luzon, with an elevation of 2,922 m, via the Ambangeg Trail, which is known for its moderate altitude range and elevation gain of approximately 1,500–2,000 m. This trail offered a safe and controlled environment, making it suitable for beginner to novice hikers while still providing moderate high-altitude exposure.

There were three sites for data collection: (1) Ambangeg Ranger Station Jump-Off, (2) Camp 1, and (3) the final site, which includes either Camp 2 or the nearby Radio Tower Station.

Sampling Design

A total of 18 participants (9 men, 9 women) were recruited for this study. The study used the convenience sampling method in recruiting qualified participants through an invitation post on social media platforms frequently visited by clients of local hiking tours. An equal number of male and female participants was ensured, despite previous findings of no significant correlation between sex and high-altitude exposure (Boos et al., 2017).

Data Collection Procedure

Sociodemographic Characteristics

Data collection included recordings of sociodemographic information to provide a comprehensive profile of the participants. Key sociodemographic details such as age, gender, hiking experience, and hiking preparation were collected to understand the baseline characteristics of each individual and to assess any potential influence these factors might have on their physiological responses to altitude.

Monitoring of Physiological Parameters

The HEM-7121 Blood Pressure Monitor Arm was used to monitor the hikers' BP, following the steps listed in the Omron device's instruction manual. A camp was set up in three designated locations along the hike. After the setup, the air plug was connected to the device's air jack. The arm cuff was then wrapped securely around the hiker's left arm. To ensure accurate results, the hiker must remain in a relaxed position. The start button was pressed to initiate its measurement. The machine then gave its reading and recording of measurements.

An Inmed Fingertip Pulse Oximeter F-120 was used for the measurement of the heart rate. According to the instruction manual by Inmed, the Pulse Oximeter was attached to the middle or index finger of the subject. The device systematically turned on upon detecting the finger. A reading of the SpO2 in the blood, as well as a reading of the heart rate of the subject, was then given. The results were then tabulated accordingly. The resting heart rate of the subject was observed three times with 1-min intervals each for calculation of the HRR.

Similar to the heart rate method, an Inmed Fingertip Pulse Oximeter F-120 was used for the measurement of SpO2 as it gives a reading for both the SpO2 and the pulse rate.

Signs and Symptoms of Acute Altitude Sickness

The Lake Louise Score Questionnaire was administered during each of the hikers' rest on the camps that were set up to assess the signs and symptoms of AMS. The questionnaire took the form of a printed questionnaire that the subjects answered based on their experience.

Environmental Parameters

At each designated site for data collection, environmental parameters, GPS position, altitude, barometric pressure, temperature, and absolute humidity were measured using the SPARKlink Air Interface PS-2011 and its mobile app SPARKvue version 4.11.2.1.

Data Extraction Tool

A detailed spreadsheet was used to ensure organized and systematic recording of all relevant information. The spreadsheet included sections for each participant's designated control number, demographic details, and specific measurements recorded throughout the study. This structured approach facilitated efficient data retrieval and analysis.

Data Analysis

Data analysis involved descriptive and inferential statistics to evaluate the gathered data comprehensively. Descriptive statistics were used to summarize and provide an overview of key variables, such as BP and SpO2. Inferential statistics, including bivariate analysis, were used to examine relationships between variables focusing on correlation.

Ethical Considerations

This study was conducted in accordance with the World Medical Association Declaration of Helsinki and the De La Salle University Code of Research Ethics. An approval letter to conduct research was secured from the mayor of Bokod, Benguet. Furthermore, no indigenous people were recruited as a participant in this study.

RESULTS AND DISCUSSION

A total of eighteen (18) participants completed the study. The participants had a mean age of 23.9 ± 5.05 years and a mean body mass index (BMI) of 21.4 ± 4.12, which both fall under the description of healthy young adults described by the Centers for Disease Control and Prevention (2024). The age and sex distribution were homogenous, with 38.9% coming from ages 20–24, 22.2% coming from ages 25–29, and another 38.9% coming from ages 30–34 (Table 1).

Table 1. Frequency Distribution of the Participant Novice Hikers According to Age and Sex (n =18)

Age Group	Male		Female		Total	
	n	%	*n*	%	*n*	%
20–24	6	33.3	1	5.6	7	38.9
25–29	0	0.0	4	22.2	4	22.2
30–34	3	16.7	4	22.2	7	38.9
Total	9	50.0	9	50.0	18	100

Table 2. Topographical and Climatic Characteristics of Designated Data Collection Site Along the Mt. Pulag Ambangeg Trail (February 22 and March 8, 2025)

	Jump-Off		**Camp 1**		**Camp 2/ Radio Tower**	
Date	Feb. 22	Mar. 8	Feb. 22	Mar. 8	Feb. 22	Mar. 8
Weather condition	clear	light rain	clear	light rain	clear	light rain
Time	2:48 a.m.	12:55 a.m.	3:54 a.m.	2:53 a.m.	6:44 a.m.	5:03 a.m.
Altitude (m)	2,475	2,487	2,582	2,582	2,824	2,729
Temperature (°C)	14.3	13.4	14.1	11.3	12.3	9.9
Barometric pressure (kPa)	74.01	74.01	72.99	72.82	70.76	71.48
Absolute humidity (g/m^3)	9.6	10.6	9.0	10.2	8.0	9.3

The climatic characteristics observed during the February 22 and March 8, 2025, field assessment are not fully comparable due to notable differences between the two data collection sessions (Table 2).

The overall weather during the first field observation was clear skies, while the second day experienced light precipitation for most of the time. This contributed to a consistently colder temperature and higher humidity during the second data collection. However, the trend of the environmental parameters across the sites from jump-off to Camp 2/Radio Tower was similar. As the trail ascended in altitude, the temperature became colder, humidity became drier, and barometric pressure dropped accordingly.

The comparability of environmental conditions across data collection is crucial for ensuring reliability of the variables of interest. Variability in observations can introduce potential confounding factors that may influence the physiological responses being measured. These are particularly important in studies involving human participants, where physiological outcomes are known to be highly sensitive to environmental conditions, including ambient temperature, humidity, and barometric pressure (Beall, 2007).

As shown in Figure 1a, elevation increased continuously across the designated three sites, from approximately 2,475 m at the jump-off to approximately 2,582 m in Camp 1 and ending in Camp 2/Radio Tower with an approximate altitude of 2,824 m in both dates. This increase coincided with observable declines in temperature, barometric pressure, and absolute humidity, which is consistent with the expected environmental responses to altitude gain (Suseno & Setyawan, 2023).

Conversely, the temperature (Figure 1b) decreased as the trail's altitude increased, falling from a mean temperature of 13.85°C at jump-off to 11.1°C at Camp 2/Radio Tower. The slightly lower temperatures on March 8 indicate not only the influence of altitude but also temporal variation, particularly the rainy weather conditions and earlier time of day. Such temperature drops with elevation reflect the typical environmental lapse rate according to the findings of Guo et al. (2024), who emphasized that cooler air at high altitudes contributes to increased metabolic respiratory stress.

The barometric pressure also showed a clear downward trend (Figure 1c), which dropped from a mean pressure of 74.01 kPa at jump-off to 71.12 kPa at Camp 2/Radio Tower. Consideration of this parameter is important since Bilo et al. (2019) and Marriott and Carlson (1996) have demonstrated that hikers exposed to such barometric pressure can have higher risk of experiencing hyperbaric hypoxia, which is a condition known to induce acute physiological responses.

Absolute humidity (Figure 1d) was also observed to have steadily declined with increased altitude. Absolute humidity was documented to have a mean of 10.1 g/m^3 at the jump-off to 8.62 g/m^3 at Camp 2/Radio Tower. The reduced atmospheric moisture at high altitude may increase respiratory water loss and irritate the airways, further escalating the symptoms of AMS, mostly for unacclimatized individuals (Savioli et al., 2022).

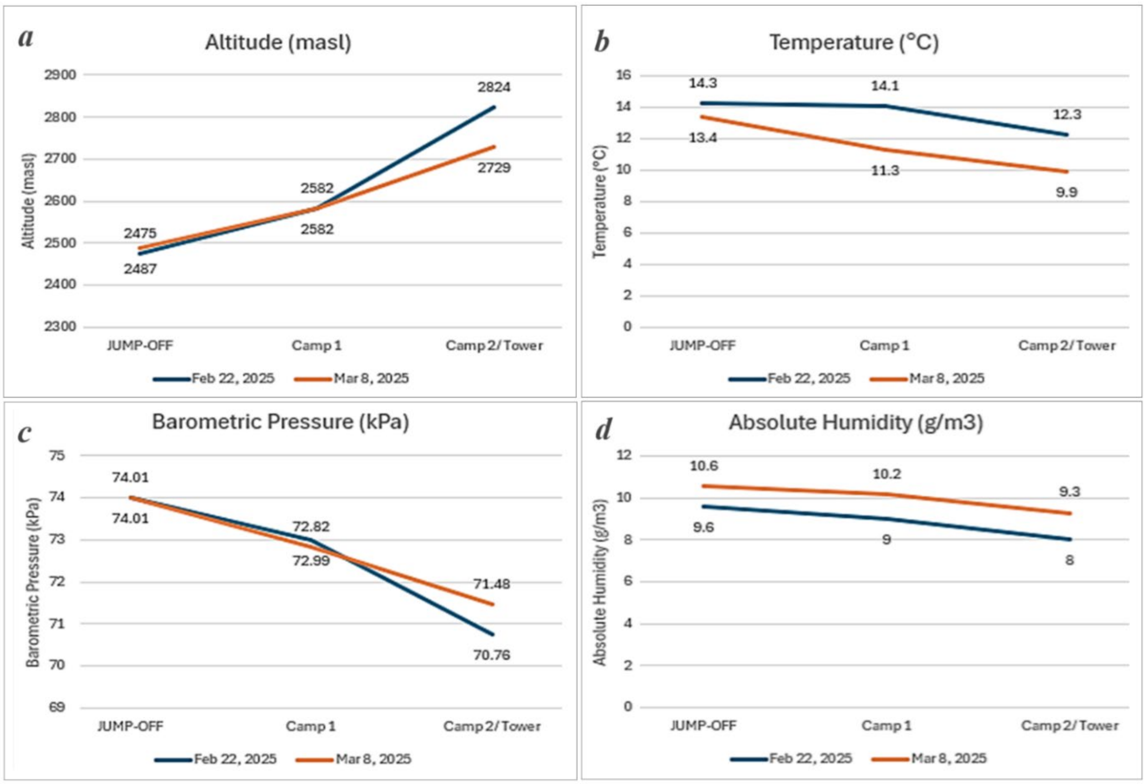

Figure 1. Topographical and climatic characteristics of designated data collection sites along the Mt. Pulag Ambangeg Trail.

In relation to this, the partial pressure of inspired oxygen (PIO_2) also declines with altitude and is calculated using the formula PIO2 = (Patm − PH_2O) × FIO2, where Patm is atmospheric pressure, PH_2O is the water vapor pressure, and FIO2 is the fraction of inspired oxygen.

There is a connection between PIO_2 and absolute humidity, as both are influenced by altitude and temperature. As absolute humidity decreases, so does the water vapor pressure (PH_2O), slightly altering the PIO_2. However, the dominant factor in PIO_2 reduction at high altitude remains the drop in atmospheric pressure. Both lower absolute humidity and PIO_2 contribute to increased respiratory strain and higher AMS susceptibility at elevation (Sevik et al., 2025).

The environmental parameters observed along Mt. Pulag Ambangeg Trail exhibit a clear altitudinal gradient seen in barometric pressure, temperature, and humidity. As elevation increases from the jump-off to Camp 2/Radio Tower, both barometric pressure and temperature show a consistent decline, while humidity showed slight variations. These changes align with the expected atmospheric behavior that is observed in higher altitudes mirroring findings from the Tromsø Study, which demonstrated that decreasing atmospheric pressure is associated with small reductions in SpO2. Despite this, such pressure drops typically do not result in increased dyspnea among individuals (Dohmen et al., 2020). Applying this to Mt. Pulag, while hikers may experience physiological changes due to decreasing pressure and temperature, the observed environmental conditions are unlikely to cause significant breathlessness in healthy individuals.

Implications for Acclimatization and Physiological Stress

These environmental conditions suggest that hikers climbing Mt. Pulag via Ambangeg Trail were gradually exposed to hypoxic stress, especially in altitudes exceeding 2,500 m. With the combination of reduced oxygen, cold temperatures, and dry air, the cardiopulmonary system takes on a considerable heavy demand that can potentially trigger AMS symptoms including headache, fatigue, and nausea (Luo et al., 2022; Sharma et al., 2023).
The stable pattern seen between February 22 and March 8 suggests that there was minimal environmental variation over time, which implies that physiological differences observed between the hikes would be attributed to acclimatization effects rather than environmental change. This aligns with the study of Burtscher et al. (2021), which emphasized the importance of gradual ascent and exposure time in promoting altitude acclimatization.

Physiological Changes During Trail Ascent

Figure 2 and Table 3 shows the changes in systolic and diastolic BP among participants throughout the jump-off, Camp 1, and Camp 2/Radio Tower. Empirically, systolic BP was shown to have a slight decrease starting from the jump-off point to Camp 2, starting from a mean systolic pressure of 127.94 ± 16.96 mmHg at jump-off decreasing to 117.72 ± 11.35 mmHg at Camp 2/Radio Tower. Diastolic BP, on the other hand, was shown to be relatively stable throughout all points with a minor increasing trend, starting from 89.0 ± 12.11 mmHg at jump-off to a slight increase with 90.39 ± 10.22 mmHg at Camp 2. Analysis of variance tests, however, revealed that these differences were not statistically significant for either mean systolic ($p = 0.079$) and diastolic ($p = 0.919$) BPs across all three points. These findings suggest BP stability in the novice hikers throughout the hike.

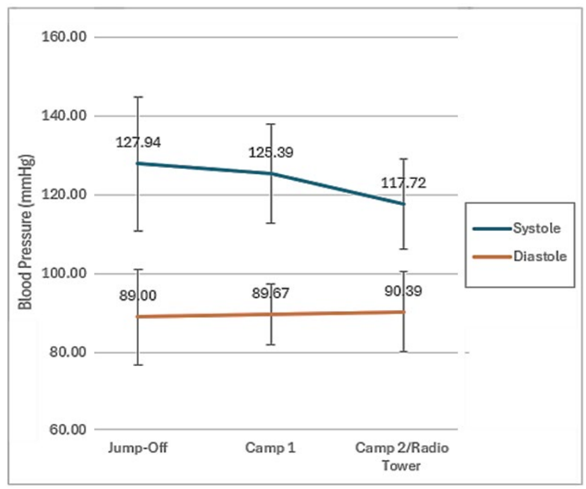

Figure 2. Comparison of the blood pressure among the participant novice hikers along the Mt. Pulag Ambangeg Trail ($n = 18$, $p < 0.05$).

Table 3. Comparison of the Blood Pressure Among the Participant Novice Hikers Along the Mt. Pulag Ambangeg Trail (n = 18, p < 0.05)

	Jump-Off	Camp 1	Camp 2/Radio Tower	*p*-Value
Systole	127.94 ± 16.96	125.39 ± 12.55	117.72 ± 11.35	0.079
Diastole	89.0 ± 12.11	89.67 ± 7.61	90.39 ± 10.22	0.919

This stability in BP can be explained by a sufficient cardiovascular ability in novice hikers to adapt to the combined stress of physical activity and higher altitude exposure during the hike. BP is defined by the product of cardiac output (CO) and systemic vascular resistance (SVR) (Trammel & Sapra, 2023).

$$BP = CO \times SVR$$

Thus, an increase in either CO or SVR or a combination of the two would result in increased BP. Pulse rate was found to be significantly increased during ascent from jump-off to Camp 1, possibly indicating an increase in cardiac output. CO is defined by the product of heart rate (HR) and stroke volume (SV) (Hall & Hall, 2020).

$$CO = HR \times SV$$

Given that there were no significant changes in BP throughout the hike despite the increase in heart rate and likely cardiac output, it can be assumed that the systemic vascular resistance must have decreased sufficiently to offset the elevated cardiac output. Thus, the BP was maintained. This decrease in systemic vascular resistance can also be represented in the slight decline of systolic BP observed (Delong & Sharma, 2023). A decrease in SVR can be attributed to exercise induced vasodilation in skeletal muscles (Hellsten et al., 2012). As the participants ascended the trail, metabolic vasodilation occurred to increase blood flow to the primary working muscle groups such as the legs during the hike. It is also worth noting that during exercise and induced hypoxia, an increase in SNS activity is expected, which causes a subsequent increase in heart rate and vasoconstriction in inactive muscles to prioritize blood flow and oxygen delivery to vital organs (Katayama & Saito, 2019). This can be represented in the minimal increase in diastolic pressure. However, due to the large vascular bed in the working lower body muscles, vasodilation in these areas has a significant effect on the lowering of the total systemic vascular resistance, enough to override sympathetic vasoconstriction through a phenomenon known as functional sympatholysis (Joyner & Casey, 2015). Due to the greater local metabolic demand, there is a net decrease in total systemic vascular resistance, enough to offset the increase in cardiac output leading to a stability in BP.

Figure 3 and Table 4shows the average pulse rate of the novice hikers as they scaled the Mt. Pulag Ambangeg Trail. There was an increase in the mean pulse rate from the jump-off (90.41 ± 13.75 bpm) to the first camp (120.17 ± 13.57 bpm). Then, a gradual downward decrease is observed from Camp 1 to the Camp 2/Radio Tower point.

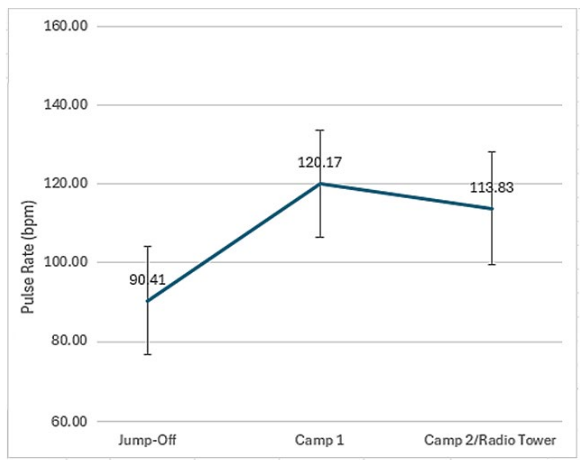

Figure 3. Comparison of the pulse rate among the participant novice hikers along the Mt. Pulag Ambangeg Trail (n = 18, p < 0.05).

Table 4. Comparison of the Mean Pulse Rate Among the Participant Novice Hikers Along the Mt. Pulag Ambangeg Trail (n = 18, p < 0.05)

	Mean Pulse Rate
Jump-off	90.41 ± 13.75
Camp 1	120.17 ± 13.57
Camp 2/Radio Tower	113.83 ± 14.26

The results are consistent with the literature surrounding the effects of altitude on heart rate. As observed from the transition between jump-off to Camp 1, the pulse rate is elevated. Table 5 displays the corresponding p-values of each station with one another, with p-values that imply that there was a significant change in pulse rate from jump-off to Camp 1 and jump-off in comparison to Camp 2/Radio Tower. Initially, the heart rate will elevate as a reaction to the perceived decrease in oxygen availability, which is a result of higher altitude and lower air pressure (Boos et al., 2017). This would cause the pulse rate to elevate as the heart would compensate for the lesser oxygen intake (Marriott & Carlson, 1996).

Table 5. Comparison Between Two Groups at a Time Based on the Pulse Rate Among Participant Novice Hikers ($n = 18$, $p < 0.05$)

Mean Pulse Rate (bpm)	*p*-Value
Jump-off vs. Camp 1	0.000
Camp 1 vs. Camp 2/Radio Tower	0.181
Jump-off vs. Camp 2/Radio Tower	0.000

During the transition from Camp 1 to Camp 2/Radio Tower, there was a slight decrease in pulse rate, with a more stable change. This could be attributed to acclimatization being the body's physiological response to the thermal variability of the high-altitude environment (Sharma et al., 2023), as it improves oxygen delivery to tissues (Berger & Luks, 2023). As a result, hypoxic pulmonary vasoconstriction occurs to ensure that oxygen reaches oxygen-deficient areas in the body. Once arterial oxygen levels stabilize, the need for the heart to pump more blood also decreases, leading to it beating at a decreased and more constant pace. This is a sign of improved oxygen circulation and reduced chemoreflex sensitivity as the SNS slowly regulates after the body has adapted. .

Figure 4 shows the results of the average SpO2 of novice hikers as they climbed Mt. Pulag Ambangeg Trail. A gradual downward trend can be observed in the mean SpO2 of the participants from the jump-off point (93.30 ± 2.30%) to Camp 1 (92.52 ± 2.47%) and further to Camp 2/Radio Tower (91.78 ± 2.65%). A visible decrease in average values can be seen; however, error bars in all locations overlap each other, making the differences not statistically significant.

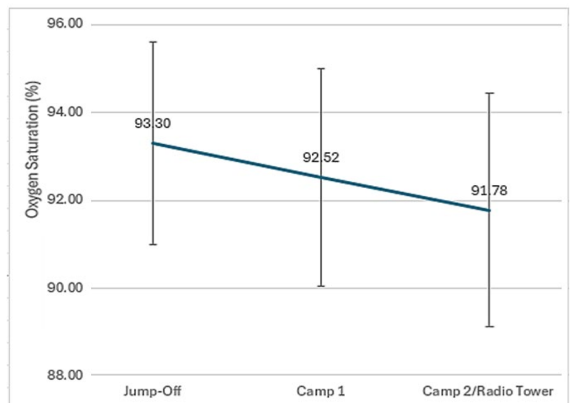

Figure 4. Comparison of the oxygen saturation among the participant novice hikers along the Mt. Pulag Ambangeg Trail ($n = 18$, $p < 0.05$).

Although the observed decline in average SpO2 is not statistically significant, these results are consistent with the existing literature on the physiological effects of climbing higher altitudes (Dohmen et al., 2020). An increase in elevation causes a decrease in atmospheric pressure and the amount of oxygen inspired. This results in less effective oxygen uptake in the lungs and reduced SpO2 in the blood. In response, the body activates compensatory mechanisms such as hyperventilation and an increased heart rate to improve oxygen delivery to tissues. The body's cardiovascular system may initially struggle to compensate for reduced oxygen availability at high altitude (Mallet et al., 2021). This results in a slight decrease in SpO2 at higher altitudes..

The Lake Louise Scores (LLS) among the participants showed no significant difference (Table 6). The Lake Louise questionnaire is used to diagnose whether the participants experienced AMS if they scored greater than three. No participant in the study was diagnosed with AMS, and all participants were able to complete the hike. Many participants also shared the same LLS for all of the points of interest, save for one participant whose LLS increased by one.

Table 6. Comparison of the Lake Louise Scores (LLS) among the Participant Novice Hikers Along the Mt. Pulag Ambangeg Trail ($n = 18$, $p < 0.05$)

Site	Lake Louise Score	*p*-Value
Jump-off	0.667 ± 1.03	0.856
Camp 1	0.667 ± 1.03	
Camp 2/Radio Tower	0.833 ± 1.04	

The symptoms listed on the LLS questionnaires are general (headache, fatigue, etc.), which often leads to the diagnosis of false positives. It could be that the symptoms that the participants experienced could be attributed to other factors like their own physiological capabilities, tolerance, and underlying illnesses, as these sets of symptoms are not exclusive to AMS (Moore et al., 2020)..

Table 7 shows the comparison of all parameters measured in the study, that is, BP, pulse rate, SpO2, and LLS. There were empirical changes in all parameters from the jump-off point to Camp 2/Radio Tower. However, only the pulse rate showed significant differences (p = 0.000), specifically from the jump-off to Camp 1. An initial significant increase in pulse rate is indicative of the body's early cardiovascular response to an increased physical exertion and a decrease in oxygen availability, primarily through an increased SNS activity (Boos et al., 2017; Katayama & Saito, 2019). This increase in pulse rate results in an increased cardiac output in order to maintain adequate delivery of oxygen in active muscles when arterial oxygen levels decline (Boos et al., 2017; West, 2012). However, rapid acclimatization occurred due to the absence of any significant changes in all parameters at higher camps, likely due to effective compensatory mechanisms such as hyperventilation and hemodynamic adjustments including exercise induced vasodilation and functional sympatholysis (Hellsten et al., 2012; Joyner & Casey, 2015; Mallet et al., 2021). Furthermore, low LLS indicate a low susceptibility to AMS in the novice hikers (Bärtsch & Swenson, 2013). These findings reflect effective cardiopulmonary adaptation even in novice hikers and suggest that novice hikers are at low risk of altitude related sickness under moderate high-altitude hiking.

Table 7. Comparison of the Blood Pressure, Pulse Rate, Oxygen Saturation, and Lake Louise Score Among the Participant Novice Hikers Along the Mt. Pulag Ambangeg Trail ($n = 18$, $p < 0.05$)

Parameters	Jump-Off	Camp 1	Camp 2/Radio Tower	p-Value
Systole (mmHg)	127.94 ± 16.96	125.39 ± 12.55	117.72 ± 11.35	0.079
Diastole (mmHg)	89.0 ± 12.11	89.67 ± 7.61	90.39 ± 10.22	0.919
Pulse rate (bpm)	90.41 ± 13.75	120.17 ± 13.57	113.83 ± 14.26	0.000
Oxygen saturation (%)	93.3 ± 2.30	92.52 ± 2.47	91.78 ± 2.65	0.195
Lake Louise Score	0.667 ± 1.03	0.667 ± 1.03	0.833 ± 1.04	0.856

It is also important to consider the acclimatization that occurred before the hike. A gradual ascend to altitude provides the body opportunities to be able to adapt to the change in altitude and climate without it being startled. The degree of acclimatization is relative to the altitude attained and the exposure experienced (Muza et al., 2010). Evidence suggests that spending one to three nights at moderate to high altitudes before further ascent can induce ventilatory acclimatization and be protective against AMS (Centers for Disease Control and Prevention, 2025; Muza et al., 2010). The current Mt. Pulag Ambangeg Back Trail hiking itinerary, as provided by event coordinators, offered this sufficient acclimatization period for the participants. In the itinerary followed by the researchers, hikers arrived in Baguio City (approximately 1,500 masl) by 3:00 a.m. and reached Mt. Pulag Ranger Station (around 2,300 masl) by 9:00 a.m. After completing registration, the hikers stayed overnight at a homestay near the jump-off point. The hike began around 2:00 a.m. the following day for those aiming to reach the Tower Station in time for the sunrise. This schedule provided nearly a 24-hr acclimatization period before the hike began which likely contributed to the mitigation of AMS and pronounced physiological changes experienced by the novice hikers.

CONCLUSION

The study assessed the effects of high-altitude hiking on the cardiopulmonary physiology of young adult novice hikers during their ascent of Mt. Pulag. Participants, classified as healthy young adults, showed general preparedness for moderate- to high-altitude exposure.

It was evident that exposure to higher elevations causes different levels of physiological changes within the body, most notably a significant increase in pulse rate during the initial ascent from jump-off (2,475 m) to Camp 1 (2,582 m) with an elevation gain of 110 m. Novice hikers also experienced minor physiological changes like the elevation of BP, as well as a decrease in SpO2 during the transition from jump-off to Camp 1, where there is a rapid increase in altitude.

As the hike progressed together with an increase in altitude, the vital signs started to stabilize at a gradual rate, with a decrease in pulse rate and an increase in SpO2. LLS, however, were consistently low throughout the hike, and no participants developed symptoms of AMS. An overnight stay near the jump-off point (2,300 masl) provided a 24-hr period of acclimatization before ascent, which likely contributed to the absence of AMS symptoms and allowed early physiological adjustment prior to further ascent.

These findings suggest effective cardiovascular compensation and acclimatization in the novice hikers, likely linked to compensatory mechanisms, such as hyperventilation and blood flow regulation. Overall, it can be concluded that short-term high-altitude exposure triggered mild physiological responses in healthy young adult novice hikers, with no occurrence of significant cardiopulmonary issues or altitude-related sickness observed. Furthermore, the itinerary's inclusion of a 24-hr period of acclimatization at moderate altitude was sufficient for novice hikers to mitigate significant physiological changes when scaling higher altitudes.

RECOMMENDATION

Several measures can be taken to enhance the safety, preparedness, and awareness of novice hikers undertaking high-altitude climbs. These include improvements in health screening, self-monitoring, prehike education, and study design for future research.

Novice hikers should undergo basic health screening before participating in high-altitude activities. Key indicators such as BP, resting heart rate, and SpO2 should be assessed to identify individuals who may be more vulnerable to altitude-related physiological stress. If any participant is found to be at risk, they are to be removed from the study to ensure their safety and reduce the likelihood of complications during the hike.

Self-monitoring can also be improved by encouraging hikers to have a personal physiological monitoring device, such as a pulse oximeter or wearable health tracker. This ensures consistent and reliable data collection throughout the hike and promotes greater awareness of individual physiological responses to altitude.

Prehike orientation sessions led by organizers or local authorities should also be mandatory. These sessions can educate participants on altitude-related symptoms, pacing, hydration, and self-care strategies. The use of tools like the Lake Louise Score Questionnaire can further support early detection of AMS and improve hikers' ability to respond to symptoms effectively. After the hike, a health assessment should be conducted to monitor for delayed effects of altitude exposure, such as AMS symptoms or postexertional fatigue. This step is important to ensure proper recovery and to gather additional data on the impact of high-altitude conditions.

Future studies should involve a larger sample size to enhance the accuracy of findings. Recruiting participants in advance will help better represent the intended demographic. It may also be valuable to explore longer acclimatization hikes with overnight stays. Future research should include older novice hikers, who may be more susceptible to cardiovascular issues but remain interested in new physical challenges later in life. Additionally, integrating subjective measures such as perceived exertion, mood, and cognitive performance can offer a more comprehensive understanding of how altitude affects not only the body but also the mind..

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