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ORIGINAL ARTICLE

Acute Mountain Sickness Symptoms Among International Students at King Khalid University: a Cross-Sectional Study

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SUMMARY

Background: **Acute mountain sickness (AMS) can significantly affect new visitors to high altitudes, especially those who ascend rapidly via air travel. This study aimed to investigate Acute Mountain Sickness symptoms among international students at King Khalid University (KKU) in Abha, Saudi Arabia, situated at 2,250 meters above sea level.**

Methods: **A questionnaire based on the Lake Louise Scoring System for AMS was distributed to international students at KKU's housing campus. The survey explored the symptoms of acute mountain sickness (headache, dizziness/lightheadedness, fatigue and or weakness, and poor appetite and nausea), severity, duration, and management provided. Demographics and body mass index were also collected. A total of 203 respondents participated in the survey, with 99.4% being male and 72% aged 20 - 29 years.**

Results: **In total, 173 (62.6%) participants reported at least one AMS symptom within the first 24 hours of arrival. Fatigue/weakness 55 (27.1%), headache 39 (19.2%), loss of appetite 22 (10.8%), and dizziness 16 (7.9%) were the most prevalent symptoms. Regarding symptom severity, 23 (17.8%) reported severe symptoms while 57 (44.2%) reported moderate symptoms. Adaptation to the high-altitude environment varied among participants, with 58 (42.3%) adapting within days and 46 (33.6%) taking weeks. Notably, 26 (19.40%) respondents were still experiencing symptoms at the time of the survey. The most common actions taken to alleviate symptoms were over-the-counter medicine in 49 (24.1.1%), followed by rest in 34 (16.7.2%) and 28 (13.8%) sought medical help. Age, nationality, or prior awareness about AMS did not correlate with AMS symptoms. Those who visited the region for the first time, had chronic symptoms or diseases or had a lower body mass index were more likely to experience AMS symptoms.**

Conclusions: **These findings showed a high prevalence of AMS symptoms among international students in Abha, Saudi Arabia, possibly because they arrived by flight. Being both a tourism destination and an academic center, a high-altitude specialized clinic and service is recommended. Further research is warranted to explore the long-term effects of high altitude on international student health and academic performance. In addition, effective strategies for mitigating altitude-related symptoms in this population should be developed.**
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INTRODUCTION

Acute mountain sickness (AMS) which affects visitors to high altitudes encompasses a range of symptoms including headache, dizziness, fatigue, shortness of breath, loss of appetite, and sleep disturbances. It is a well-documented phenomenon that affects individuals who ascend to elevations usually above 2,500 meters [1]. The incidence of AMS at around 2,500 meters altitude is approximately 20 - 25%, increasing to 40 - 50% at 4,000 meters. Altitudes lower than 2,500 meters are also associated with acute symptoms, especially in those who arrive quickly with no available time for acclimatization. Saudi Arabia has a different topography that includes heavily inhabited altitudes as high as 3,000 meters above sea level.

The pathophysiology of altitude sickness involves the body's response to lower oxygen levels (hypoxia) at higher elevations [2,3]. AMS results from cerebral vasodilation in response to hypoxemia, a universal physiological reaction at high altitudes that is more pronounced in those who develop AMS. When extreme, the expansion of cerebral blood vessels results in increased brain volume, reduced intracranial compliance, and temporary elevations in intracranial pressure (ICP) [4].

In individuals not acclimatized to high altitude, symptoms, like headache, dizziness, fatigue, shortness of breath, loss of appetite, and sleep disturbances are common upon arrival at altitude. Rarely, these symptoms can progress to life-threatening high-altitude pulmonary edema (HAPE) or high-altitude cerebral edema (HACE), though these are rare at elevations below 3,500 meters. Humans living at high altitudes are well adapted genetically to the decreased inspired oxygen [1]. Travel to high altitudes has become very common for various reasons including tourism, exploration, and other causes [5,6]. Travelers from originally low-altitude regions lack the physiological adaptations of high-altitude long-term dwellers and thus are exposed to physiological challenges they are usually unaccustomed to. Many symptoms can develop acutely for travelers to high altitude collectively called AMS. These symptoms are contributed mainly by hypoxemia but complex mechanisms including hypoventilation, nocturnal desaturation, and increased cerebral blood flow are also involved. Most individuals will start to adapt to high altitude shortly upon arrival with most of the AMS symptoms resolving within a few days. Complete acclimatization however can take months to complete [7].

King Khalid University (KKU) is located at an altitude of 2,250 meters above sea level in Abha, southern Saudi Arabia. Many international students are enrolled and many new people come each year. According to the 2022 census, more than 2,000 students from 73 different countries are enrolled in the university. These students usually arrive to Abha via air travel with no time available to acclimatize. While AMS is widely reported in higher altitudes, fewer reports explore altitudes less than 2,500 m. This study aimed to explore the prevalence of acute mountain sickness symptoms on newly arriving individuals to Abha city which is located at an altitude traditionally considered lower than which may result into altitude related symptoms. The international students were chosen due to ease of administering the questionnaire to a uniform group of individuals with the aim to inform the clinical practice and advise future students and tourists coming to our high-altitude region.

MATERIALS AND METHODS

This study was approved by the ECM at KKU (ECM #2024-3153). This research employed a cross-sectional study design using a self-administered questionnaire, which was distributed electronically to international student groups and in person among international students at KKU in Abha, Saudi Arabia. The study was conducted between September and December 2024. For simplicity, the target population consisted of international students enrolled at KKU. All international students aged 18 and above were eligible to participate. From a reported population of over 2,000 international students, the study aimed for a sample size of 322 participants. This sample size was calculated using a 95% confidence level, 5% margin of error, and an expected prevalence of 50% to ensure a conservative estimate.

A structured questionnaire was developed based on the Lake Louise Scoring System for AMS diagnosis, assessing symptoms such as headache, dizziness/lightheadedness, fatigue/weakness, and poor appetite/nausea on a severity scale from 0 to 4 [8,9]. Questions about disturbed sleep, although not part of the AMS score, were also included as the aim was to gather a wide perspective of symptoms experienced. The survey was developed using Google Forms and delivered in Arabic Language. The survey began with an introductory page outlining the purpose of the study, ethical approval, and assurances that no personally identifiable information would be collected. It also emphasized that all data would be handled with strict confidentiality. Participants provided their consent electronically before proceeding with the survey. Assistance was provided for non-Arabic speakers to ensure accurate completion. Basic demographics and anthropometric data were also collected like country of origin, duration of stay in Abha, number of visits, previous exposure to high altitude, chronic diseases, and height and weight, if known. BMI index was calculated as weight (kg) divided by the squared height (m) and considered normal if 19 - 24, overweight if 24 - 29, and obese if > 30. Descriptive

statistics, frequency, and percentage were reported to summarize demographic data and symptom, and chi-squared tests to examine associations between variables.

RESULTS

A total of 203 participants completed the survey. The sample was predominantly male (99.5%), 73.4% aged between 20 and 29 years, 19.7% were from Arab countries, 70.9% had been residing there for 1 - 3 years, 17.7% for less than a year, and 11.3% for more than four years (Figure 1). In terms of BMI, 63.1% had a normal BMI, 20.7% were classified as overweight, and 16.3% were obese. A significant proportion of participants, 75.4% reported that this was their first visit to Abha, 13.8% had prior experience with high-altitude environments, though infrequently, and 10.8% indicated frequent visits to the region before the survey. Most participants, 72.9%, reported no chronic diseases or symptoms. Among those who did, the most commonly reported conditions included migraines or other recurrent headaches (11.8%), cardiorespiratory issues (5.9%), panic attacks (3%), and other unspecified conditions (2%). Nearly, four-fifths (69.5%) of the participants reported no awareness about symptoms associated with high altitude whereas 62 (30.5%) reported some awareness (Table 2).

Difficulty sleeping was the most commonly reported symptom (32%), followed by fatigue and general weakness (27.1%), and shortness of breath (24.6%). Headache was reported by 19.2%, with 19 (9.4%) describing it as severe. Other neurological symptoms included imbalance, reported by 8.4%, and confusion or hallucinations, reported by 7.4%. Dizziness was experienced by 7.9%. Gastrointestinal symptoms were less common, 10.8% reported loss of appetite, and 4.9% experienced nausea and vomiting. Notably, 37.4% reported no symptoms at all as shown in Table 2.

Excluding sleep disturbances, which are common at high altitudes even among long-term residents, the prevalence of AMS symptoms was estimated at 62.5%. Among those who experienced symptoms, 14% reported severe AMS symptoms, while moderate symptoms were more prevalent, affecting 44.2%, followed by mild symptoms in 38%. The duration of AMS symptoms varied; 42.3% reported that their symptoms were resolved within days, 33.6% within weeks, and 7 participants reported symptoms persisting for longer than weeks. Additionally, 19% indicated they were still experiencing persistent symptoms at the time of the survey.

Regarding symptom management, 24.1% used over-the-counter medications, while 16.7% managed their symptoms through rest and reduced activity. Increased fluid intake was employed by 8.4%, and 13.8% sought medical help. A small proportion, 2.5%, required supplemental oxygen, while 21.7% did not take any specific actions to address their symptoms.

Exploring potential baseline characteristics associated with the occurrence of AMS symptoms revealed that age, nationality, and awareness of AMS were not significantly associated with symptom occurrence (Table 3). However, a normal BMI was found to be significantly associated with the presence of AMS symptoms ($p = 0.048$). The presence of chronic diseases demonstrated the strongest correlation with AMS symptoms ($p = 0.001$), followed by the duration of stay in the region ($p = 0.049$).

DISCUSSION

AMS is a crucial consideration in patients presenting various complaints shortly after arrival at high altitudes, affecting approximately 50% of visitors. Acute exposure to a hypoxic environment in previously unacclimatized individuals is the hallmark of AMS (10). Although AMS is reported mainly at higher altitudes (> 2,500 m), it does happen even at lower altitudes, more so with rapid ascent to altitude like those arriving by air travel.

There is an increasing prevalence and severity of AMS with the level of altitude. However, the prevalence of AMS is related to many factors and not merely a function of altitude. The prevalence of AMS in our study is about 62.5%. Most of the respondents were young male students coming from coastal East African countries which put them at particularly increased risk. Despite being a moderate altitude, the prevalence of AMS in our study (62.5%) is higher than that reported in the Swiss Alps (9%) but lower than that observed among trekkers to Mount Kilimanjaro, Tanzania (75%) [11]. The reported prevalence from Mount Fuji (3,776 m) in Japan was 29.5% [12]. It should be noted that these areas involve stepped and gradual altitudes to the maximum tops and visitors usually arrive at the summit gradually over many days. This could explain the variable prevalence described in different studies. Flying to high altitude limits the time of acclimatization and was found to be associated with a 4.5-fold increase in the risk of AMS [13].

This study showed a high prevalence of AMS symptoms with shortness of breath, headache and fatigue being the common symptoms. This is despite KKU's elevation being below the typical threshold for acute mountain sickness. While most of these symptoms were transient and resolved within days, as expected with acute mountain sickness, a substantial percentage reported chronic symptoms with a potential implication for student well-being and academic performance, given that 25% of respondents were still experiencing symptoms at the time of the survey. This is evident as 72.3% have visited doctors for their symptoms. Almost 14% of the participants reported continuing symptoms at the time of the survey which begs the question of whether those individuals are going to experience the more troublesome chronic mountain sickness.

Individual risk factors played important roles in the de-

Table 2. Frequency of symptoms, severity, duration and management of acute mountain sickness.

Immediate symptoms		Number	Percentage	Severe symptoms		Number	Percentage
Within the first 24 hours of your arrival in Abha, did you experience any of the following symptoms?	headache	39	19.20%	Have you experienced any of the following severe symptoms since arriving in Abha?	severe shortness of breath (even at rest)	21	10.30%
	nausea or vomiting	10	4.90%		cough (with or without pink foamy phlegm)	33	16.30%
	dizziness or feeling dizzy	16	7.90%		chest tightness or rapid heartbeat	20	9.90%
	difficulty sleeping	65	32.00%		severe headache that does not respond to medications	19	9.40%
	shortness of breath (especially with exertion)	50	24.60%		imbalance	17	8.40%
	fatigue or weakness	55	27.10%		confusion	11	5.40%
	loss of appetite	22	10.80%		hallucinations	4	2.00%
	others	7	3.40%		none	124	61.10%
	none	76	37.40%	If you have symptoms of altitude sickness, have you done any of the following?	never had symptoms	68	33.50%
If yes, severity of these symptoms	mild	49	38.00%		rest or reduce physical activity	34	16.70%
	moderate	57	44.20%		increased fluid intake	17	8.40%
	severe	23	17.80%		take over-the-counter pain relievers (such as ibuprofen)	49	24.10%
Have these symptoms persisted or recurred since your first arrival?	disappeared within days	58	42.30%		seek medical help	28	13.80%
	disappeared within weeks	46	33.6%		use of supplemental oxygen	5	2.50%
	months to disappear	6	4.4%		I didn't take any specific action	44	21.70%
	yes, it's still going on	26	19.0%				

Table 3. Correlations of symptoms of Acute Mountain Sickness (Pearson's chi-squared test).

Age in years	0.57
Gender	0.225
Nationality	0.677
Body mass index	0.048
Chronic diseases	0.001
Duration of living in SA	0.049
Have you ever experienced living at high altitudes (above 2,500 meters) before coming to Abha?	0.361
Before you came to Abha, did you have any information that visiting high areas for the first time may be accompanied by symptoms such as headache and nausea?	0.767

		Number	Percentage
Age (years)	< 20	6	3%
	20 - 29	149	73.4%
	30 - 39	44	21.7%
	> 40	4	2%
Gender	Male	201	99.5%
	Female	2	0.5%
Nationality	Non Arabs	163	80.3%
	Non Saudi Arabs	40	19.7%
Body Mass Index	Normal Weight	128	63.1%
	Over-weight	42	20.7%
	Obese	33	16.3%
Duration of living in SA	< 1 year	36	17.7%
	1 - 3 years	144	70.9%
	4 - 5 years	13	6.4%
	> 5 years	10	4.9%
Living at Altitude. (> 2200 meters) before coming to SA)	Yes, Frequnetly	22	10.8%
	Yes, Infrequently	28	13.8%
	NO	153	75.4%
Chronic disease	None	148	72.9%
	Migraine / Chronic headache	24	11.8%
	Respiratory diseases	7	3.4%
	cardiac diseases	5	2.5%
	ENT diseases	3	1.5%
	GIT diseases	3	1.5%
	Panic Attacks	6	3%
	Bone diseases	2	1%
	Others	5	2.5%

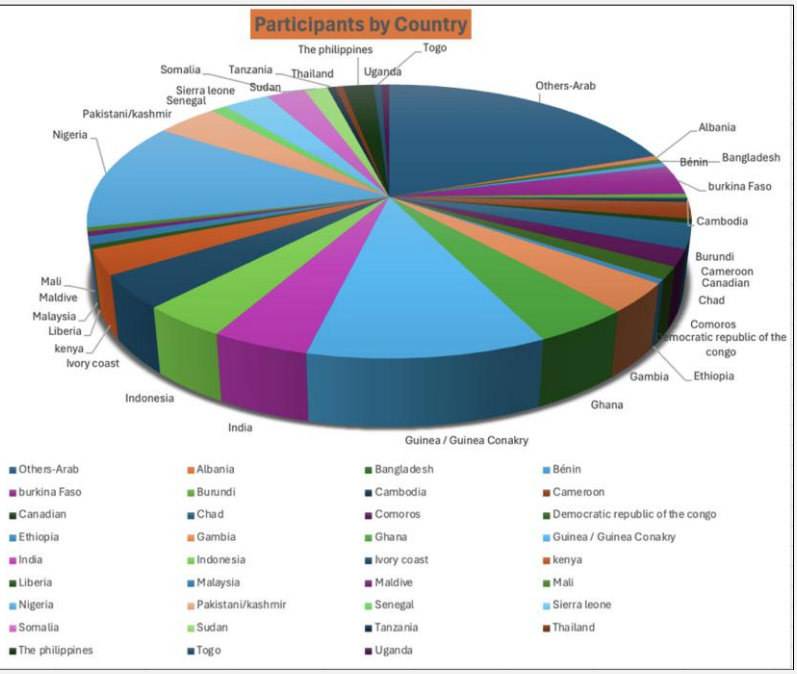

Figure 1. Demographic characteristics and country of origin for study participants.

velopment of AMS. Some studies reported that awareness of the risk decreased the occurrence of AMS in frequent trekkers to altitude [14]. Our study did not show the same, possibly because our respondents do not have the means to mitigate the risk as their arrival is restricted to air travel. Studies showed that younger age groups are particularly at risk and aging seems to be a protective factor [15]. Those coming originally from a higher altitude area are less likely to develop AMS compared to sea-level residents. Previous exposure does not seem to be protective [16]. There is conflicting evidence about the role of comorbid conditions where most studies report that individual factors are more important. For example, patients with migraine were found to have a higher risk but not those with high blood pressure [17]. Interestingly athletes are at increased risk due to their baseline lower ventilatory drive. In the absence of other comorbidities, age was not thought to be a major factor [18]. The is also conflicting evidence on the gender factor where females are considered at a lower risk [19]. While age was not found to be a factor in our study, it should be noted that our respondents are uniformly younger, and almost all are male population.

The care provided for these symptoms was largely symptomatic. While 72% visited the doctors, most participants reported receiving painkillers with the symptoms abating within days. Drugs known to be used for the management of AMS were not prescribed even for those who had severe symptoms. This might indicate a lack of awareness of the primary health provider of this pathological entity and how it should be managed. To our knowledge, there is no dedicated high-altitude clinic. High altitude physiology is not taught in undergraduate medical curricula nor in postgraduate clinical training programs. We think such specialized service is particularly needed in our region that has many destinations for tourists. It is imperative that those with chronic diseases should be counseled before traveling to high altitude [20].

Preventive strategies are available for the prevention or alleviation of severity of AMS. Acetazolamide is a diuretic that counteract cerebral vasodilation and is proven beneficial in case of AMS, and dexamethasone and ibuprofen can be used [21]. Sumatriptan was also effective for treatment of severe AMS symptoms, the same agents utilized for prevention can be used [22]. In case of persistent severe symptoms and when presentation heralds the onset of cerebral edema, descent to lower altitude is needed. Gradual ascent is considered the best strategy for prevention of AMS. Unfortunately, for many this is not possible as air travel continues to be the main mode of transportation for visitors from outside the region [23].

Strengths and limitations:
The study employed a robust cross-sectional design, utilizing a structured questionnaire based on the widely recognized Lake Louise Scoring System to AMS symptoms among international students at KKU. The inclusion of additional symptoms, such as sleep disturbances, provided a broader perspective on participants' experiences at high altitudes. The study involved mainly young and healthy populations so the prevalence cannot be generalized. It was limited by the inherited design where recall bias in self-reported symptoms and their severity is possible. The age and gender factors were not explored, and the respondents were mainly males (99.4% male respondents).
Implication of the study: the findings of this study suggest that demographic factors such as age, nationality, and prior awareness of AMS were not significantly associated with symptom occurrence, challenging assumptions that familiarity with high-altitude environments reduces risk. This reinforces the need for universal education and preventive measures regardless of background. Overall, the study provides valuable insights for policymakers, healthcare providers, and educational institutions, emphasizing the importance of proactive measures to mitigate AMS symptoms and improve the quality of life for individuals living in or visiting high-altitude regions.

CONCLUSION

The prevalence of AMS is notably high among students visiting the Aseer region, particularly affecting newcomers who ascend rapidly. Establishing a dedicated high-altitude clinical service is recommended to educate healthcare providers, offer preventive advice, and provide appropriate treatment for those affected. Future studies are needed to explore the long-term effects of moderate altitude exposure on student health and academic performance.

Informed Consent:
Informed consent was obtained from all participants before completion of the study questionnaire.

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Data Availability Statement:
The dataset used during this study is available.

Declaration of Interest:
No potential conflict of interest was reported by the author(s).

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