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*Full Length Research Paper*

# A survey of acute mountain sickness and vital signs in subjects ascending to Lhasa via the Qinghai-Tibet train

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**Since the opening of Qinghai-Tibet Railway in July 2006, much remains to be learned regarding the incidence of acute mountain sickness (AMS) while train travelers are moving along the Qinghai-Tibet Railway and after their arrival in Lhasa. We surveyed 49 subjects traveling from Chongqing (300 m) to Lhasa (3,658 m) via the Qinghai-Tibet train. In the current study, we sought to determine: the incidence of AMS on the moving Qinghai-Tibet train upon arrival in Lhasa and during the first five days in Lhasa, the vital signs and physiological variables of the train travelers on the 7th and 30th days following their arrival in Lhasa. AMS was seen in 0% of subjects in this study in Xining, 0% in Golmud, 8.2% in Tanggula, 14.3% in Lhasa, 14.3% during the first two days in Lhasa and 0% during the third through 5th days in Lhasa. Headaches, dizziness, and poor appetite were the most common symptoms induced directly by hypoxia in this study. On the 7th day after arriving in Lhasa, the average forced vital capacity (FVC) was 3,175.3 ± 385.6 ml, which was remarkably lower than that on the 30th day (3,322.6 ± 435.1 ml, $P < 0.01$). The results of the current study suggest that the incidence of AMS associated with travelers from Chongqing to Lhasa on the Qinghai-Tibet train is very low among subjects. Furthermore, physiological measurements taken during hypoxia acclimatization showed an increase in FVC following acclimatization.**

**Key words:** Acute mountain sickness (AMS), Qinghai-Tibet Railway, Lhasa.

## INTRODUCTION

Acute mountain sickness (AMS) is defined as a headache plus one of the following symptoms: loss of appetite, nausea, vomiting, fatigue/weakness, dizziness, and insomnia, and a Lake Louise Scoring System (LLSS) score greater than 3 when individuals ascend rapidly from low to high altitude of more than 2,300 m (Hackett and Roach, 2001; Maggiorini et al., 1998; Roach, 1993). The symptoms typically develop within 6 to 10 h after ascending, but can sometimes occur as early as 1 h after ascending. The incidence of AMS ranges from 10 to 93%, depending on the rate of ascent, the height reached, and the method of ascent (Basnyat et al., 2000; Gertsch et al., 2002; Honigman et al., 1993; Pradhan et al., 2009).

Studies have been conducted at various altitudes after rapid ascents, while others after more gradual ascent. Examples include studies of physically healthy young men ascending to altitudes above 3,658 m on foot (Hackett et al., 1976), by plane (Murdoch , 1995; Ren et al., 2010) or when they were transported from sea level to the summit (4,205 m) over a period of 3 h (Gertsch et al., 2002). Transportation of subjects on the railway reflects a different mode and rate of transport to high altitude for which we have little data. Since the Qinghai-Tibet Railway opened in July 2006, there has been a

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growing need for increased knowledge regarding the incidence of AMS on the moving Qinghai-Tibet train and during the first five days after ascending to Lhasa. It is well known that subjects must acclimatize to high altitude conditions. Acclimatized subjects experience up-regulated cardiovascular system function with decreased systolic blood pressure, increased pulse pressure (PP), rapid heart rate (HR), increased forced vital capacity (FVC), and a faster respiratory rate (RT) (Basu et al., 2007; Koller et al., 1991). However, previous studies have not examined vital signs and physiological variables in visitors on the 7th and 30th days after their arrival in Lhasa by train.

In the current study, we surveyed 49 young male subjects traveling from Chongqing to Lhasa on the Qinghai-Tibet train. The information obtained from this study should be useful for developing strategies to minimize AMS symptoms in all travelers ascending to Lhasa, and could help determine vital signs and physiological variables associated with hypoxia acclimatization on the 7th and 30th days after arriving in Lhasa by train.

## Subjects

In June 2009, 49 subjects traveled from Chongqing (300 m) to Lhasa (3,658 m) by train and remained in Lhasa for two months to gain clinical experience in mountain sickness. These young men were a tightly controlled group of recruits. All of them were young recruits in the Third Military Medical University, and all of them were healthy. The train passed through Xining (2,200 m), Golmud (2,800 m) and the Tanggula (5,200 m), and reached Lhasa (3,658 m) after 44 h of travel. The AMS questionnaire used for the present study was designed to obtain demographic information regarding the age, height, weight, and permanent residence of each traveler. To make this questionnaire validate, the documentation of the demographic survey was performed by high altitude medicine physicians. During the course of this study, all subjects were instructed not to use any medicine or supplemental oxygen (except that already supplied to all passenger) to prevent AMS without a physician's permission. Written consent was obtained from all subjects in agreement with the guidelines from the ethical committee of the Third Military Medical University.

## METHODS

### Incidence of AMS on the train and during the first five days after ascending to Lhasa

Forty-nine healthy young men left Chongqing (300 m) by train, and arrived in Lhasa, Tibet (3,658 m) 44 h later. The current study was conducted to determine the incidence of AMS on the train and during the first five days after ascending to Lhasa in a tightly controlled group of recruits. When the train was moving along, the incidence of AMS symptoms was determined in Xining (2,200 m), Golmud (2,800 m), and Tanggula (5,200 m), immediately after getting off the train in Lhasa (3,658 m), and during the first five days after arriving in Lhasa by train. At the same time, arterial blood pulse oxygen saturation ($SpO_2$) and heart rate (HR) were recorded using the TuffSat Oximeter Handheld Pulse Oximeter (GE, USA); the $SpO_2$ probe was set on the right index finger. When traveling on the train, $SpO_2$ levels were measured when the train was at the railway station. Within 30 min of the measurements, all of the subjects had rested and had not eaten or exercised. During the first five days after their ascent to Lhasa, $SpO_2$ levels were measured before the subjects got up every morning. The pulse oximetry was measured for an average of 30 s with a steady value.

In order to determine whether the travelers had experienced AMS, they were asked if they had experienced any of the following symptoms: headache, loss of appetite, nausea, vomiting, fatigue/weakness, dizziness, or insomnia. Clinical symptoms and signs were recorded by high altitude medicine physicians. AMS was diagnosed based on the LLSS score. AMS was diagnosed when a traveler's daily activities were influenced by headache symptoms plus one of the following symptoms: loss of appetite, nausea, vomiting, fatigue/weakness, dizziness, and insomnia (Roach, 1993). When headaches symptoms did not occur, an LLSS score greater than 3 was required to diagnose AMS. All subjects filled out the AMS questionnaire within the first hour after arriving at each destination site. After the young men reached Lhasa, they filled out the questionnaire once a day for five days in the evening before going to sleep.

### Measurements of vital signs and physiological variables on the 7th and 30th days

At 7 and 30 days after the 49 healthy young men arrived in Lhasa, their blood pressure (OMRON, China), $SpO_2$, HR, respiration rate (RT), and forced vital capacity (FVC) (Nantong Weighing Apparatus Factory, China) were measured in order to determine whether changes occurred during hypoxia acclimatization after traveling to Lhasa by train.

### Statistical analyses

Data are expressed as mean ± SD, and were analyzed using a paired T analysis with SPSS12.0 software, the significant difference was accepted when $P < 0.05$.

## RESULTS

The overall demographics were as follows: age range: 22 to 26 years (average: 22.9 ± 1.06 years); body weight range: 52 to 78 kg (average: 64.93 ± 6.06 kg); and 43/49 (87.8%) of the travelers had never been to the plateau, while the remaining 6 travelers had visited the plateau in the past. Among these 6 travelers, the most recent trip to the plateau was made four years ago.

## Changes in $SpO_2$ levels and HR on the moving train and during the first five days after reaching Lhasa

$SpO_2$ levels peaked in Chongqing (97.1 ± 0.8%) and gradually declined with the rise in elevation. $SpO_2$ levels

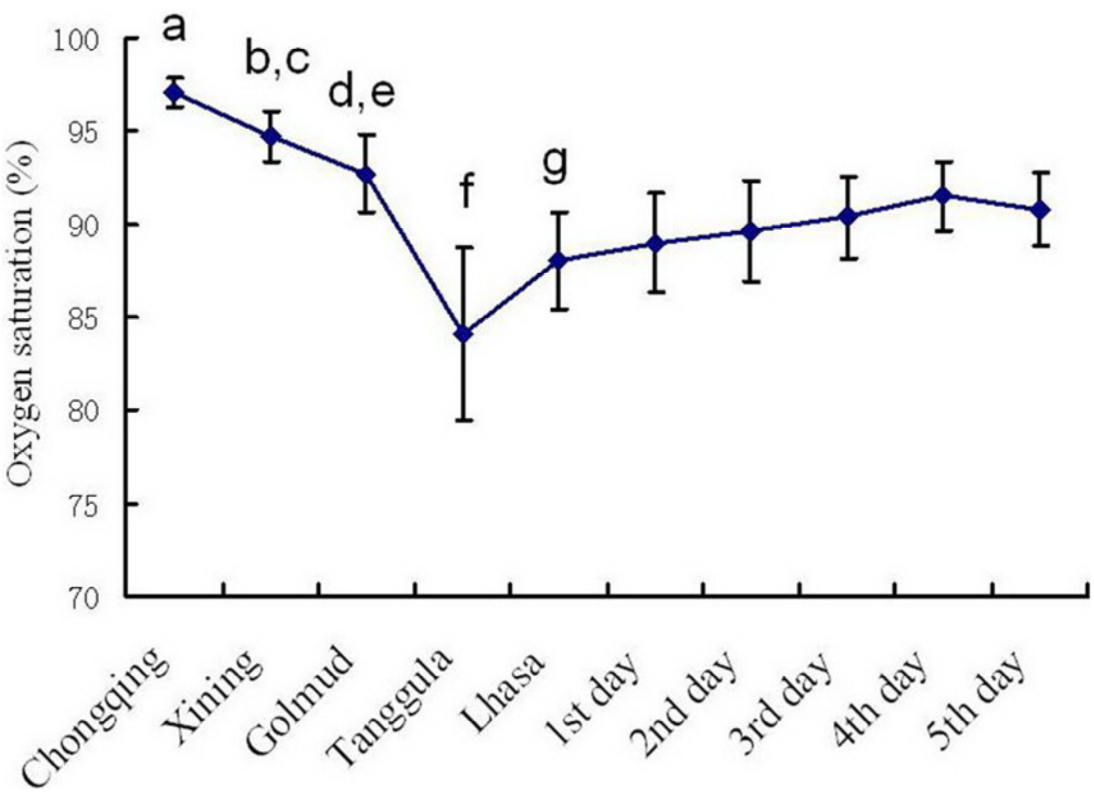


**Figure 1.** Changes in arterial blood oxygen saturation and their correspondence with altitude in 49 subjects.

[a]P < 0.01 vs. Xining (2,200 m), Golmud (2,800 m), Tanggula (5,200 m), Lhasa (3,658 m), 1st day (3,658 m), 2nd day (3,658 m), 3rd day (3,658 m), 4th day (3,658 m), and 5th day (3,658 m); [b]P < 0.01 vs. Golmud, Tanggula, Lhasa, 1st, 2nd, 3rd, 4th, and 5th day; [c]P < 0.05 vs. 4th day; [d]P < 0.01 vs. Tanggula, Lhasa, 1st, 2nd, and 3rd day; [e]P < 0.05 vs. 2nd day; [f]P < 0.01 vs. 1st, 2nd, 3rd, 4th, and 5th day; and [g]P < 0.01 vs. 4th day.

were 94.7 ± 1.3% in Xining and 92.7 ± 2.1% in Golmud. From Golmud onward, oxygen levels inside the Qinghai-Tibet train were maintained at 24.1 to 25.3% by increasing the inspired oxygen concentration; in this way, the effective altitude can be reduced from 900 to 1,200 m (West 2008). At the peak altitude of the Tanggula (5,200 m), the minimum $SpO_2$ value was only 84.1 ± 4.6%; after continuing on to Lhasa (3,658 m) with a decrease in altitude, $SpO_2$ levels rose to 88.0 ± 2.6%. With increased time in Lhasa, $SpO_2$ levels increased gradually to 89.0 ± 2.6% on the first day, 89.6 ± 2.7% on the second day, 90.4 ± 2.2% on the third day, 91.5 ± 1.9% on the fourth day, and 90.8 ± 2.0% on the fifth day (Figure 1).

As the altitude increased from Chongqing, the HRs of the travelers increased gradually from 81.6 ± 10.6 beats/min in Chongqing, to 75.0 ± 11.8 beats/min in Xining, 74.1 ± 10.3 beats/min in Golmud, 94.1 ± 13.2 beats/min in the 5,200 m altitude of the Tanggula, and finally to 95.5 ± 13.4 beats/min in Lhasa. After arriving in Lhasa, the average HR was 88.4 ± 12.9 beats/min on the first day, 83.4 ± 13.0 beats/min on the second day, 82.7 ± 13.5 beats/min on the third day, 84.0 ± 15.2 beats/min on the fourth day, and 86.4 ± 16.3 beats/min on the fifth day (Figure 2).

### AMS incidence on the moving train and during the first five days after ascending to Lhasa

In Golmud, only 1 person (2.1%) had a mild headache. In Tanggula, the most common symptom was mild dizziness (28.6%), and the second most common symptom was poor appetite or nausea (10.2%). In Lhasa, the most frequent symptom was headaches (16.3%), including mild (14.2%) and moderate (2.1%) headaches, and the second most frequent symptom was dizziness (10.2%). From the third day on, few of the travelers experienced symptoms. None of the 49 travelers exhibited signs or symptoms of high altitude pulmonary edema (HAPE) or high altitude cerebral edema (HACE) (Table 1). The percentage of AMS among the 49 young men was 0% in Xining, 0% in Golmud, 8.2% in Tanggula, 14.3% in Lhasa, 14.3% on the first and second days after arriving in Lhasa, and 0% on the third through fifth days after

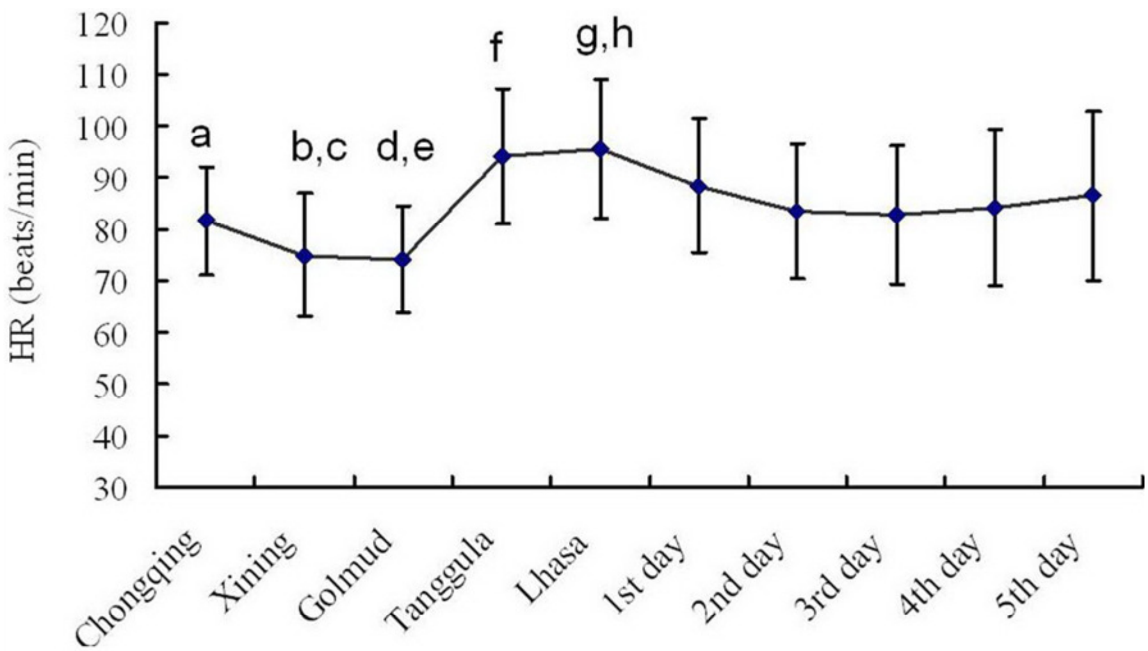


**Figure 2.** Changes in HR corresponding to altitude in 49 subjects. [a]P < 0.01 vs. Tanggula and Lhasa; [b]P < 0.01 vs. Tanggula, Lhasa, 1st day, and 5th day; [c]P < 0.05 vs. 4th day; [d]P<0.01 vs. Tanggula, Lhasa, 1st day, 4th day, and 5th day; [e]P<0.05 vs. 2nd day and 3rd day; [f]P < 0.01 vs. 2nd day, 3rd day, and 4th day; [g]P < 0.01 vs. 2nd day, 3rd day, and 4th day; and [h]P < 0.05 vs. 5th day.

arriving in Lhasa (Table 2). The LLSS scores ranged from 0 to 4, and only 3 travelers had LLSS scores of 4 at the Tanggula on the first and second days after arriving in Lhasa (Table 2).

### Vital signs and physiological variables on the 7th and 30th days after arriving in Lhasa

On the 7th day after arriving in Lhasa, the average RT was 18.96 ± 3.67 respirations/min, with 11 travelers having an RT greater than 20 respirations/min and 8 travelers having an RT less than 16 respirations/min. On the 30th day, the average RT was 19.20 ± 2.65 respirations/min, with 11 travelers having an RT greater than 20 respirations/min and 4 travelers having an RT less than 16 respirations/min. On the 7th day, the average HR was 83.69 ± 11.42 beats/min, with 12 travelers having an HR greater than 90 beats/min. On the 30th day, the average HR was 85.83 ± 15.87 beats/min, with 17 travelers having an HR greater than 90 beats/min. The average systolic blood pressure (SBP) was 130 ± 10 mm Hg on the 7th day and 124 ± 10 mm Hg on the 30th day. 20 travelers on the 7th day and 16 travelers on the 30th day had SBP values greater than 130 mm Hg. The average diastolic blood pressure (DBP) was 83 ± 9 mm Hg on the 7th day and 83 ± 8 mm Hg on the 30th day. On the 7th day 9 travelers and on the 30th day 10 travelers had DBP values greater than 90 mm Hg. The average pulse pressure (PP) on the 7th day (46.18 ± 10.00 mm Hg) was higher than that on the 30th day (41.14 ± 10.63 mm Hg, P < 0.05). On the 7th day, the average FVC of the travelers was 3,175.3 ± 385.6 ml, which was lower than that on the 30th day (3,322.6 ± 435.1 ml, P < 0.01) (Table 3).

## DISCUSSION

This study surveyed visitors who traveled from Chongqing to Lasha via the Qinghai-Tibet train. Among the 49 subjects train passengers, 8.2% had AMS on the train at the Tanggula (5,200 m), 14.3% had AMS when they arrived in Lhasa, and 14.3% had AMS on their first and second days in Lhasa. As time went on, few of the young subjects experienced AMS.

$SpO_2$ levels gradually decreased with increasing elevation and reached a minimum level of only 84.1 ± 4.6% when the train passed the peak elevation at the Tanggula. It is well documented that atmospheric pressure and alveolar oxygen partial pressure decline with an increase in altitude, which directly affects the alveolar gas exchange, blood oxygen levels, and the integration of the speed. After ascending to the plateau, the decreasing $SpO_2$ levels may result in an insufficient supply of oxygen. Hypoxia can induce the stimulation of the carotid and aortic body chemoreceptor reflex, which can in turn lead to a rapid HR (Koller et al., 1991). In the

**Table 1**. AMS symptoms incidence relative to altitude among 49 young men traveling on the Qinghai-Tibet train.

| Symptoms | Xining {N (%)} | Golmud {N (%)} | Tanggula {N (%)} | Lhasa {N (%)} | Day 1 {N (%)} | Day 2 {N (%)} | Day 3 {N (%)} | Day 4 {N (%)} | Day 5 {N (%)} |
|---|---|---|---|---|---|---|---|---|---|
| **Headache** | | | | | | | | | |
| No headache | 0 (0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| Mild headache | 0 (0) | 1 (2.1) | 2 (4.1) | 7(14.3) | 6 (12.3) | 7 (14.3) | 1 (2.1) | 1 (2.1) | 1 (2.1) |
| Moderate headache | 0(0) | 0(0) | 0(0) | 1(2.1) | 1(2.1) | 0(0) | 0(0) | 0(0) | 0(0) |
| Severe headache, incapacitating | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| **Gastrointestinal symptom** | | | | | | | | | |
| No gastrointestinal symptoms | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| Poor appetite or nausea | 0(0) | 0 (0) | 5 (10.2) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Moderate nausea or vomiting | 0(0) | 0(0) | 1(2.1) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| Severe nausea or vomiting, incapacitating | 0 (0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| **Fatigue and/or weakness** | | | | | | | | | |
| Not tired or weak | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| Mild fatigue/weakness | 0(0) | 0(0) | 3(6.1) | 1(2.1) | 3(6.1) | 5(10.2) | 4(8.2) | 3 (6.1) | 3 (6.1) |
| Moderate fatigue/weakness | 0(0) | 0(0) | 3(6.1) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| Severe fatigue/weakness, incapacitating | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| **Dizziness/lightheadedness** | | | | | | | | | |
| Not dizzy | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| Mild dizziness | 0(0) | 0 (0) | 14(28.6) | 5(10.2) | 6(12.2) | 6(12.2) | 2(4.1) | 1(2.1) | 0(0) |
| Moderate dizziness | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| Severe dizziness, incapacitating | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| **Difficulty sleeping** | | | | | | | | | |
| Slept as well as usual | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| Did not sleep as well as usual | 1(2.1) | 0(0) | 0(0) | 1(2.1) | 0(0) | 2(9.6) | 1(2) | 0(0) | 0(0) |
| Woke many times, poor night's sleep | 0(0) | 0(0) | 1 (2.1) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| Unable to sleep | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |

AMS: acute mountain sickness; Xining (2,200 m), Golmud (2,800 m), Tanggula (5,200 m), Lhasa (3,658 m), Day 1 (3,658 m), Day 2 (3,658 m), Day 3 (3,658 m), Day 4 (3,658 m), and Day 5 (3,658 m).

current study, at the highest elevation of the Tanggula, the average HR (94.1 ± 13.2 beats/min) was faster than at the lower elevations. However, the average HR values were slightly faster in Chongqing. The reason for this increase may be due to the fact that HR measurements were acquired 1 h after the travelers had left the train; they had carried their luggage to the train and may not have had enough time to rest.

Varying levels of oxygen, ranging from 24.1 to 25.3%, were supplied to increase the inspired oxygen concentration inside the Qinghai-Tibet train (West, 2008), which can reduce the effective altitude from approximately 900 to 1,200 m. Among the 49 subjects, the incidence of AMS (8.2%) at the Tanggula experienced on the Qinghai-Tibet train was lower than that of Western tourists near the Thorang pass (5,400 m) in Nepal (Kayser, 1991), this may be due to the fact that oxygen was supplied on the train. According to the results of the current study, the AMS incidence among the young travelers who arrived in Lhasa by train was lower on the first and second days (that is, 14.3%) than the AMS incidence among travelers who flew directly from 300 m to Lhasa (that is, 57.2%), (Ren, 2010). Ren (2010) surveyed 3,628 new army recruits who traveled to Lhasa (3,658 m) by air; the AMS incidence rate was 57.2%. The subjects in his study were similar to those in our study: all of them were young men who were not acclimatized to high altitude. In the current study, we found that young visitors who traveled by train to Lhasa had a lower AMS incidence rate than those who traveled by air to Lhasa. A

**Table 2.** The LLSS of AMS relative to altitude among 49 young men traveling on the Qinghai-Tibet train.

| Score | Xining {N (%)} | Golmud {N (%)} | Tanggula {N (%)} | Lhasa {N (%)} | Day 1 {N (%)} | Day 2 {N (%)} | Day 3 {N (%)} | Day 4 {N (%)} | Day 5 {N (%)} |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 48(97.9) | 47(95.9) | 29(59.2) | 37(75.4) | 37(75.5) | 35(71.5) | 46(93.9) | 47(95.9) | 48(97.9) |
| 1 | 1(2.1) | 2(4.1) | 11(22.4) | 10(20.2) | 11(22.4) | 12(24.4) | 3(6.1) | 2(4.1) | 1(2.1) |
| 2 | 0(0) | 0(0) | 6(12.2) | 0(0) | 0(0) | 2(4.1) | 0(0) | 0(0) | 0(0) |
| 3 | 0(0) | 0(0) | 2(2.1) | 1(2.1) | 0(0) | 0(0) | 0(0) | 0(0) | 0(0) |
| 4 | 0(0) | 0(0) | 1(2.1) | 1(2.1) | 1(2.1) | 0(0) | 0(0) | 0(0) | 0(0) |
| AMS incidence | 0(0) | 0(0) | 4(8.2) | 7(14.3) | 7(14.2) | 7(14.3) | 0(0) | 0(0) | 0(0) |

LLSS: Lake Louise Scoring System.

**Table 3.** Vital signs in 49 healthy young men on the 7th and 30th days following their ascent by train to Lhasa.

| Item | 7th day | | 30th day | |
|---|---|---|---|---|
| RT (rate/min) | 18.96 ± 3.67 | | 19.20 ± 2.65 | |
| Exceed 20 rate/min (n and mean ± SD) | 11/49 (22.4%) | 24.36 ± 2.73 | 11/49 (22.4%) | 22.73 ± 1.42 |
| Less than 16 rate/min (n and mean ± SD) | 8/49 (16.3%) | 14.12 ± 0.64 | 4/49 (8.2%)[a] | 13.75 ± 0.95 |
| R (rate/min) | 83.69 ± 11.42 | | 85.83 ± 15.87 | |
| Exceed 90 rate/min (n and mean ± SD) | 12/49 (24.5%) | 98.17 ± 5.41 | 17/49 (34.7%) | 103.06±12.43 |
| Less than 50 rate/min (n and mean ± SD) | 0/49 (0%) | - | 0/49 (0%) | - |
| SBP (mm Hg) | 130±10 | | 124±10 | |
| Exceed 130 mm Hg (n and mean ± SD) | 20/49 (40.7%) | 138 ± 7 | 16/49 (32.7%) | 135 ± 3 |
| Less than 90 mm Hg (n and mean ± SD) | 0/49 (0%) | - | 0/49 (0%) | - |
| DBP (mm Hg) | 83 ± 9 | | 83 ± 8 | |
| Exceed 90 mm Hg (n and mean ± SD) | 9/49 (18.4%) | 95 ± 3 | 10/49 (20.4%) | 94 ± 3 |
| Less than 60 mm Hg (n and mean ± SD) | 0/49 (0%) | - | 0/49 (0%) | - |
| Pulse pressure (mm Hg) | 46.18 ± 10.00 | | 41.14 ± 10.63[a] | |
| Forced vital capacity (ml) | 3,175.3 ± 385.6 | | 3,322.6 ± 435.1 [b] | |

RT: respiratory rate; HR: heart rate; SBP: systolic blood pressure; DBP: diastolic blood pressure; [a]P < 0.05 vs. 7th day; [b]P < 0.01 vs. 7th day.

graded ascent is often considered to be the best prophylaxis for AMS. Rapid ascents are associated with greater rates of armys. In the present study, the subjects spent two days (44 h) on the train with 24.1 to 25.3% oxygen concentrations from Golmud; during this time, they underwent a passive ascent and were exposed to a hypoxic environment. Exercise training at these high altitude environments has been shown to be beneficial for adaptation to hypoxia (Cai et al., 2010). As the train moved from Chongqing to Lhasa, the altitude gradually increased, and this graded ascent should allow the body to acclimatize to the hypoxic environment. Therefore, ascending to Lhasa by the Qinghai-Tibet train, rather than by plane, may reduce the incidence of AMS.

Notably, the LLSS scores were very low in the current study, with many ranging from 0 to 3; only 3 travelers had LLSS scores of 4 at the Tanggula, on the first and second days after arriving in Lhasa. In the current study, headaches, dizziness, and poor appetite were the most common symptoms induced by altitude-associated hypoxia.

Average PPs were greater than 40 mm Hg on the 7th and 30th days, but the PP on the 7th day was higher than that on the 30th day. An increase in PP may exacerbate myocardial ischemia by simultaneously raising the afterload and decreasing coronary perfusion (Dart and Kingwell, 2001; Franklin et al., 1997). Meanwhile, FVCs on the 7th day were remarkably lower than on the 30th day. The increased FVC on the 30th day may be caused by adjustment to a high altitude environment. Thus, with hypoxia acclimatization, the young men had a higher FVC and a slightly lower PP after they had been living in

Lhasa for 30 days.

## Conclusions

The results of the current study show that subjects traveling to Lhasa in oxygenated train cars were with a decreased incidence of AMS, a marked resolution of decreased vital capacity over time at Lhasa, and similar PP recovery levels with acclimatization.

## ACKNOWLEDGMENTS

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