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Differences Between the ''Chinese AMS Score'' and the Lake Louise Score in the Diagnosis of Acute Mountain Sickness

Jialin Wu, Haoran Gu, and Yongjun Luo

Abstract: The Chinese AMS score (CAS) is used in clinical medicine and research to diagnosis acute mountain sickness (AMS). However, the Lake Louise Score (LLS) is the well-accepted standard for diagnosing AMS. The difference between the CAS and LLS questionnaires is that the CAS considers more nonspecific symptoms. The aim of the present study was to evaluate differences in AMS prevalence according to the LLS and CAS criteria. We surveyed 58 males who traveled from Chongqing (300 m) to Lhasa (3658 m) via the Qinghai-Tibet train. Cases of AMS were diagnosed using LLS and CAS questionnaires in a few railway stations at different evaluation areas along the road. We subsequently evaluated discrepancies in values related to the prevalence of AMS determined using the 2 types of questionnaires (CAS and LLS). The prevalence of CAS-diagnosed AMS indicated that the percentage of AMS cases among the 58 young men was 29.3% in Golmud, 60.3% in Tanggula, 63.8% in Lhasa, 22.4% on the first day after arrival in Lhasa, 27.6% on the second day, 24.1% on the third day, and 12.1% on the fourth day. The prevalence of LLS-diagnosed AMS in Golmud was 10.3%, 38% in Lhasa, and 6.9% on day 1, the prevalence in each station was lower than that as assessed by the CAS. Our experimental data indicate that AMS diagnoses ascertained using the CAS indicate a higher AMS prevalence than those ascertained using the LLS. Through statistical analysis, the CAS seems capable of effectively diagnosing AMS as validated by LLS (sensitivity 61.8%, specificity 92.7%).

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Abbreviations: AMS = acute mountain sickness, AUC = area under the receiver-operating characteristic curve, CAS = Chinese AMS score, CI = confidence interval, LLS = Lake Louise Score, OOP = optimal operating point.

INTRODUCTION

Acute mountain sickness (AMS) is a kind of clinical syndrome complex taking place when people move from plain to a plateau or from a plateau to a higher altitude over a short period of time. The AMS syndrome includes headache and vomiting, and also the following symptoms: nausea, insomnia, gastrointestinal distress, fatigue/weakness, dizziness/light headedness, difficulty sleeping, and so on.[1–3] AMS can be diagnosed only in the absence of confounding factors such as alcohol consumption. A diagnosis is made when the patient has a headache and a Lake Louise Score (LLS) ≥3 and has ascended rapidly from a low altitude to a high altitude above 2500 m.[4–8] The prevalence of AMS ranges from 10% to 93%, depending on the rate of ascent, the destination altitude, and the method of ascent.[8–12] For example, 10% of subjects contracted AMS in Vardy et al's[13] study from 3000 to 4000 m; Honigman et al's[10] experimental results were 25% at 6300 to 9700 feet; and Van Roo et al's[14] study indicated 77.3% at 6962 m on Aconcagua.

To diagnose AMS, many high-altitude disease physicians and studies use the LLS, which is the gold standard for diagnosing AMS and includes questions regarding dizziness, headache, fatigue, sleep, and gastrointestinal discomfort.[14–16] In addition, some Chinese doctors continue to diagnose AMS using the ''Chinese AMS score'' (CAS), which was developed at the Chinese Medical Association's 1996 Third Ad Hoc Committee on High Altitude Illnesses[17,18] (Table 1). The difference between the LLS and the CAS is the inclusion of headache and vomiting as nonspecific symptoms in the CAS, and both of them can diagnose AMS alone; moreover, the CAS includes many indexes, including dizziness, nausea, palpitation, short breath, chest distress, dazzling, sleeplessness, anorexia, abdominal distension, diarrhea, constipation, cyanosis of the lips, lethargy, and numbness of the extremities. The CAS and the LLS have been used to diagnose AMS in many applications reported in the current literature; however, it is unclear whether the different criteria of the 2 methods result in differences in their determinations of AMS prevalence. In the present study, we surveyed 58 young males who traveled from Chongqing to Lhasa via the Qinghai-Tibet train. More specifically, we evaluated the difference in AMS prevalence determined via diagnoses determined by CAS and LLS criteria.

METHODS

Subjects and Methods

Fifty-eight young healthy males were included in this study. Ten of the travelers had been to the plateau; 4 of these had developed AMS and recovered from treatment, but it all happened in the experiment which occurred 2 or more years ago. The Qinghai-Tibet train started in Chongqing (300 m); passed through Xining (2200 m), Golmud (2800 m), and Tanggula (5200 m); and finally arrived at Lhasa (3658 m) after 44 hours of travel. Before the experiment, we used a questionnaire to collect basic information from the participants. The questionnaire included the following demographic information for each traveler: age, height, weight, ethnicity, and permanent residence. High-altitude disease physicians performed

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TABLE 1. Assessment of the Degrees and Scores Determined by the CAS

Symptoms	Degree	Score
Headache		
No headache, no suffering expression, no effect on daily activity.	±	1
Mild headache with suffering expression; obvious improvement of headache after taking regular analgesic medicine; no effect on daily activity.	+	2
Moderate headache with suffering expression; slight improvement of headache after taking regular analgesic medicine; daily activity is affected.	++	4
Severe and unbearable headache; in bed and unable to get up; no effect of regular analgesic medication.	+++	7
Vomiting		
Vomiting 1 to 2 times/d, which does not interfere with daily activities.	+	2
Vomiting 3 to 4 times/d, which interferes with daily activities.	++	4
Vomiting more than 3 times/d; patients confined to bed and no relief after medication.	+++	7
Others		
Dizziness/light-headedness, nausea, palpitation, short breath, chest distress, dazzling/blurred vision, sleeplessness (insomnia), anorexia, abdominal distension diarrhea, constipation, cyanosis of the lips, lethargy, and numbness of the extremities		1 point each

CAS = Chinese AMS score.

documentation of the demographic survey. Participants suffering from AMS were able to receive treatment during the course of this study. However, no one required drug treatment throughout the entire duration of the experiment. The ethical committee of the Third Military Medical University in China approved this study.

Study Setting

In August 2012, the experimental group traveled from Chongqing (300 m) to Lhasa (3658 m) by train and remained in Lhasa. The current study was conducted to determine the prevalence of AMS on the train and during the first 4 days after ascension to Lhasa, and to assess whether the prevalence of AMS was different when the LLS or the CAS was used for diagnoses. As the train traveled to Tibet, the prevalence of AMS symptoms was determined for each of the following stations: Xining (2200 m), Golmud (2800 m), the Tanggula (5200 m), immediately upon arrival in Lhasa (3658 m), and during the 4 days after arriving at Lhasa.

Data Collection

To diagnose AMS based on the LLS, the travelers were asked to complete an AMS questionnaire that asked about the following symptoms: dizziness, headache, fatigue, sleep, and gastrointestinal discomfort. Each symptom was scored based on a 4-grade scale that ranged from 0 (none or not present) to 3 (severe or incapacitating), with a combined score ranging from 0 to a maximum score of 15. Clinical symptoms were recorded by high-altitude disease physicians. AMS was diagnosed for cases of headache and the LLS $\geq$3.[13,19]

Concurrently, AMS was assessed using the CAS questionnaire, which asked about the following symptoms: headache, dizziness, heart palpitations, nausea, shortness of breath, chest distress, dazzling/blurred vision, anorexia, abdominal distension, diarrhea, constipation, cyanosis of the lips, lethargy, and numbness of the extremities. Headache +, vomiting +, or a total score of 5 to 10 was defined to diagnose mild AMS. Headache ++ or +++, vomiting ++ or +++, or a total score $\geq$11 was required to diagnose moderate to severe AMS (Table 2). Each of the subjects completed both the CAS and the LLS questionnaires within 1 hour of arriving at each station. During the first 4 days after reaching Lhasa, the subjects completed questionnaires once each day before going to sleep. All questionnaires were completed while subjects were in a resting state, and both types of scores were obtained at the same time point and under the same physical conditions. Before the beginning of the experiment, we had made a detail instruction on the 2 questionnaires and appropriate psychological counseling for the participants. Meanwhile, each participant had the same high-altitude disease physician to explain and assist in completing the questionnaire, so that we could, to a certain extent, reduce symptoms of judgment and data record errors.

Statistical Analyses

All statistical analyses were performed using IBM SPSS Statistics 21.0 (IBM Corp, Armonk, NY). The prevalence of AMS was presented as both the number of subjects and the percentage of subjects (from the sample) diagnosed with AMS. General descriptive statistics for each of the variables were presented as the mean (SD). Linear regression, and Spearman (rho) and Kendall (tau) rank correlation tests were used to compare the LLS and the CAS. All tests pertaining to

TABLE 2. Assessment of the Severity and Grade of CAS Evaluations

Degree	Score/Grade
Normal (±)	Total score of 1–4 points
Mild (+)	Headache+, or vomiting+; or total score of 5–10 points
Moderate (++)	Headache++, or vomiting++; or total score of 11–16 points
Severe (+++)	Headache+++, or vomiting+++; or total score 16 points

CAS = Chinese AMS score.

significance were 2-sided; $P < 0.05$ indicated a significant difference, whereas $P < 0.01$ indicated a very significant difference.

The area under the receiver-operating characteristic curve (AUC) (95% confidence interval [CI]) was evaluated using Swets classification[20]: AUC = 0.5, the test has no diagnostic value; $0.5 < \text{AUC} \leq 0.7$, the test is accurate to only a small degree; $0.7 < \text{AUC} \leq 0.9$, the test is fairly accurate; $0.9 < \text{AUC} \leq 1$, the test is highly accurate; AUC = 1, the test is perfect. Optimal operating point (OOP) was determined based on the maximum Youden index (Youden index = sensitivity + specificity − 1).

RESULTS

Volunteer Characteristics

Fifty-eight volunteers participated in the study; the detail baseline characteristics of these subjects are shown in Table 3. All subjects completed the required questionnaires throughout the duration of the experiment.

AMS Symptoms at Each Location as Assessed by the LLS

The prevalence of the 5 AMS symptoms evaluated by the LLS changed in different ways during the progression of the experiment. Headache, dizziness, sleep disturbance, and fatigue had the same tendencies that began to appear in Xining, after which their prevalence increased as the train traveled into Tibet and reached the terminus Lhasa. These 4 symptoms were determined in 35 (60.3%), 41 (70.7%), 13 (22.4%), and 41 (70.7%) subjects, respectively, in Lhasa. Four days after reaching Lhasa, the prevalence of each symptom gradually decreased to 4 (6.9%), 8 (13.8%), 3 (5.1%), and 6 (10.3%), respectively. Although Tanggula is the highest altitude on the route, the rate of occurrence of AMS symptoms was not the highest at this location (Table 4).

AMS Symptoms at Each Location as Assessed by CAS

Although the CAS questionnaire considered more symptoms than the LLS questionnaire, most of the CAS-evaluated symptoms exhibited the same trend toward change. The occurrences of headache, dizziness, heart palpitations, shortness of breath, insomnia, dazzling, anorexia, abdominal distension, and cyanosis of the lips all increased with increasing elevation. The highest rates were obtained in Tanggula or Lhasa, after which they gradually decreased. The prevalence of dizziness in Lhasa was 41 (70.7%), which was the highest rate of all the symptoms considered (Table 5).

TABLE 3. Basic Characteristics of the Volunteers (n = 58)

Variables	Mean ± SD or Proportion
Age, yrs	23.25 ± 1.45
Sex (% male)	100%
Height, cm	172.10 ± 5.28
Weight, kg	65.91 ± 6.78
BMI	22.25 ± 2.00
Smoking, %	16 (27.59%)
Ethnicity, %	
Han	54 (93.11%)
Dong	1 (1.72%)
Tujia	2 (3.45%)
Bai	1 (1.72%)
Ever been to the plateau, %	10 (17.24%)
Have a history of AMS, %	4 (6.90%)

AMS = acute mountain sickness, BMI = body mass index.

CAS and LLS Questionnaire Scores (for AMS Diagnoses) at Each Location

Table 6 depicts the relationship between CAS and LLS scores, based on the total number of points indicating the sum of all symptoms. The general descriptive statistics for variables were presented as the mean (±SD) and 95% CI. These CAS and LLS scores indicated the average values at each site. The CAS score increased gradually from Xining to Tanggula, with a highest score of 3.18 (±2.18) in Tanggula. Subsequently, the CAS score slowly decreased to 0.53 (±1.45) on day 4 after reaching Lhasa. The trend of change in the LLS score was the same as that observed for the CAS, also increasing initially and then decreasing. However, in the latter case, the maximum score was 2.34 (±1.34) in Lhasa and 0.36 (±0.93) on day 4 after reaching Lhasa. The average score in Tanggula was significantly different from those obtained in Xining, Golmud, and for days 1 to 4, as assessed using the CAS ($P < 0.01$). The average LLS score in Lhasa was also significantly different from that obtained in Xining, Golmud, Tanggula, and for days 1 to 4 ($P < 0.05$).

Scatter diagrams show the distribution relationship between CAS and LLS diagnoses at each altitude (Figures 1 and 2). In Tanggula, the CAS and LLS scores have statistically significant and positive linear correlation: rho = 0.64, tau = 0.53, $R^2 = 0.52$, $P < 0.01$, and Pearson = 0.72. In Lhasa, rho = 0.50, tau = 0.43, $R^2 = 0.31$, $P < 0.01$, also indicating a significant correlation, and Pearson = 0.56, indicating a linear correlation of moderate intensity.

Relationship Between CAS and LLS-determined Prevalence

The experimental data indicate that AMS prevalence tended toward change in a manner consistent with the changes reflected by diagnosis scores. When diagnosed using the LLS, the prevalence of AMS in Golmud was 10.3% (6/58); 29.3% (17/58) in Tanggula; 38.0% (22/58) in Lhasa, the highest rate obtained; and 6.9% (4/58), 5.2% (3/58), 1.7% (1/58), and 5.2% (3/58), respectively, the 4 days after reaching Lhasa. The highest AMS prevalence, as determined by the CAS, was 63.8% (37/58) in Lhasa and 60.3% (35/58) in Tanngula. For the 4 days after reaching Lhasa, the CAS-determined AMS prevalence was 22.4% (13/58), 27.6% (16/58), 24.1% (14/58), and 12.1% (7/58), respectively. The prevalence determined by the peak of each scoring system was consistent with the other, and the highest prevalence was observed in Lhasa, although it wasn't the maximum altitude on the route (Figure 3). AMS assessments made by both the CAS and the LLS in Lhasa showed significant differences from those obtained in Golmud and Tanggula and on days 1 to 4 (a) $P < 0.05$: compared with Golmud, Tanggula, and day 1, day 2, day 3, and day 4, as assessed by the CAS were 0.026, 0.040, 0.021, 0.005, 0.000, 0.000, respectively. (b) $P < 0.05$: compared with Golmud, Tanggula, and day 1, day 2, day 3, and day 4, as assessed by the LLS were 0.000, 0.021, 0.000, 0.000, 0.000, 0.000, respectively.

Diagnostic Accuracy of the CAS

The LLS, the gold standard, was consistent with the ROC curve obtained with the CAS at Tanggula (Figure 4). The AUC

TABLE 4. AMS Symptoms at Each Location as Assessed by the LLS (n = 58)

Symptoms	Xining	Golmud	Tanggula	Lhasa	Day 1	Day 2	Day 3	Day 4
Headache	11 (19.0%)	15 (25.9%)	32 (55.2%)	35 (60.3%)	10 (17.2%)	6 (10.3%)	5 (8.6%)	4 (6.9%)
Dizziness	15 (25.9%)	26 (44.8%)	39 (67.2%)	41 (70.7%)	17 (29.3%)	15 (25.9%)	11 (19.0%)	8 (13.8%)
Sleep disturbance	2 (3.4%)	10 (17.2%)	12 (20.7%)	13 (22.4%)	10 (17.2%)	10 (17.2%)	6 (10.3%)	3 (5.1%)
Gastrointestinal distress	0	8 (13.8%)	7 (12.1%)	5 (8.6%)	1 (1.7%)	0	1 (1.7%)	0
Fatigue/weakness	6 (10.3%)	20 (34.4%)	21 (36.2%)	41 (70.7%)	29 (50.0%)	24 (41.4%)	9 (15.5%)	6 (10.3%)

Xining (2200 m), Golmud (2800 m), Tanggula (5200 m), Lhasa (3658 m), day 1 (3658 m), day 2 (3658 m), day 3 (3658 m), day 4 (3658 m). AMS = acute mountain sickness, LLS = Lake Louise score.

TABLE 5. The Symptoms of AMS at Each Location as Assessed by the CAS (n = 58)

Symptoms	Xining	Golmud	Tanggula	Lhasa	Day 1	Day 2	Day 3	Day 4
Headache	12 (20.7%)	14 (24.1%)	35 (60.3%)	37 (63.8%)	11 (19.0%)	15 (25.9%)	13 (22.4%)	6 (10.3%)
Vomiting	0	1 (1.7%)	1 (1.7%)	1 (1.7%)	0	0	0	0
Dizziness	18 (31.0%)	27 (46.6%)	36 (62%)	41 (70.7%)	17 (29.3%)	21 (36.2%)	13 (22.4%)	6 (10.3%)
Numbness of the extremities	0	2 (3.4%)	1 (1.7%)	2 (3.4%)	23 (39.7%)	1 (1.7%)	3 (5.1%)	1 (1.7%)
Heart palpitations	6 (10.3%)	6 (10.3%)	13 (22.4%)	8 (13.8%)	2 (3.4%)	6 (10.3%)	4 (6.9%)	3 (5.1%)
Shortness of breath	4 (6.9%)	6 (10.3%)	13 (22.4%)	16 (27.6%)	7 (12.1%)	19 (32.8%)	12 (20.1%)	3 (5.1%)
Cyanosis of the lips	4 (6.9%)	25 (43.1%)	35 (60.3%)	14 (24.1%)	16 (27.6%)	11 (19.0%)	7 (12.1%)	3 (5.1%)
Lethargy	0	5 (8.6%)	7 (12.1%)	1 (1.7%)	13 (22.4%)	3 (5.1%)	4 (6.9%)	0
Blurred vision	1 (1.7%)	4 (6.9%)	4 (6.9%)	7 (12.1%)	3 (5.1%)	5 (8.6%)	2 (3.4%)	1 (1.7%)
Insomnia	3 (5.1%)	7 (12.1%)	4 (6.9%)	7 (12.1%)	7 (12.1%)	9 (15.5%)	7 (12.1%)	4 (6.9%)
Anorexia	0	4 (6.9%)	4 (6.9%)	1 (1.7%)	3 (5.1%)	0	0	0
Abdominal distension	8 (13.8%)	11 (19.0%)	19 (32.8%)	7 (12.1%)	9 (15.5%)	5 (8.6%)	4 (6.9%)	1 (1.7%)
Diarrhea	0	4 (6.9%)	2 (3.4%)	5 (8.6%)	6 (10.3%)	3 (5.1%)	2 (3.4%)	1 (1.7%)
Constipation	2 (3.4%)	3 (5.1%)	7 (12.1%)	3 (5.1%)	3 (5.1%)	2 (3.4%)	0	1 (1.7%)
Others	4 (6.9%)	0	3 (5.1%)	5 (8.6%)	0	0	5 (8.6%)	2 (3.4%)

AMS = acute mountain sickness.

for the CAS was 0.865 (0.759–0.971; $P < 0.01$), which means that the CAS fairly accurately diagnosed AMS validated by LLS. The maximum Youden index was 0.667, the sensitivity was 76.5%, and the specificity was 90.2%. The OOP was 0.76 on the y-axis and 0.09 on the x-axis (sensitivity 76.5%, specificity 90.2%), and the best cut-off CAS score was 3.5. When the CAS score equaled 5, the sensitivity and specificity were 61.8% and 92.7%, respectively.

DISCUSSION

The aim of this study was to evaluate differences in AMS prevalence determined by the LLS and CAS diagnosis criteria.

TABLE 6. CAS and LLS Questionnaire Scores of AMS at Each Location (n = 58)

	CAS			LLS								
	Mean (SD)	CI (95%)	Range	Mean (SD)	CI (95%)	Range	Pearson	rho	tau	R^2	P	n
Xining	1.09 (1.49)	0.72, 1.50	0, 7	0.59 (0.94)	0.36, 0.86	0, 4	0.69	0.61	0.56	0.48	<0.01	58
Golmud	2.00 (2.08)	1.48, 2.57	0, 9	1.43 (1.51)	1.05, 1.84	0, 5	0.50	0.42	0.37	0.25	<0.01	58
Tanggula	3.18 (2.18)*	2.53, 3.78	0, 8	1.96 (1.48)	1.42, 2.33	0, 5	0.72	0.64	0.53	0.52	<0.01	58
Lhasa	2.60 (1.89)	2.12, 3.06	0, 7	2.34 (1.34)†	1.96, 2.73	0, 6	0.56	0.50	0.43	0.31	<0.01	58
Day 1	1.84 (1.97)	1.51, 2.36	0, 7	1.22 (1.25)	0.99, 1.67	0, 5	0.63	0.72	0.62	0.40	<0.01	58
Day 2	1.69 (2.00)	1.22, 2.26	0, 7	0.97 (1.14)	0.67, 1.28	0, 4	0.63	0.59	0.50	0.39	<0.01	58
Day 3	1.26 (1.75)	0.91, 1.61	0, 6	0.55 (0.99)	0.34, 0.81	0, 4	0.76	0.75	0.68	0.58	<0.01	58
Day 4	0.53 (1.45)	0.22, 0.91	0, 7	0.36 (0.93)	0.16, 0.69	0, 4	0.70	0.69	0.65	0.49	<0.01	58

CAS = Chinese AMS score, CI = confidence interval, LLS = Lake Louise score, SD = standard deviation.
*$P < 0.01$: compared with the score of Xining, Golmud, day 1, day 2, day 3, and day 4.
†$P < 0.01$: compared with the score of Xining, Golmud, Tanggula, day 1, day 2, day 3, and day 4.

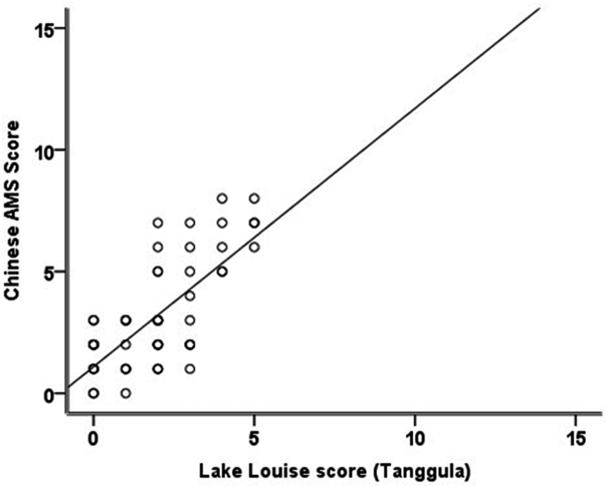

FIGURE 1. Correlation between the CAS and the LLS in the diagnosis of AMS in Tanggula. The solid line represents the fitting trend between the CAS and the LLS. Open circles represent the CAS and the LLS scores of each participant. rho = 0.64, tau = 0.53, $R^2 = 0.52$, Pearson = 0.72, and $P < 0.01$. AMS = acute mountain sickness, CAS = Chinese AMS score, LLS = Lake Louise score.

This experiment was unique in that AMS prevalence was measured by both scoring systems at different stations located at different elevations along the train's route to explore similarities and differences in the respective AMS diagnoses.

The data indicate that the AMS prevalence assessed by the LLS was 29.3% in Tanggula (5200 m) and 38.0% in Lhasa (3658 m) (Figure 3). In past studies, researchers have obtained different diagnosis results using the LLS. Vardy et al's[13] study indicated an AMS prevalence of 10% from 3000 to 4000 m, and Chen et al[19] found an AMS prevalence of 17.11% in 339 subjects at 3200 m. Newcomb et al[21] reported that 21% of subjects suffered AMS at 4470 m, and Van Roo et al's[14] study reported that 77.3% of subjects suffered AMS at 6962 m in Aconcagua. The prevalence of AMS assessed by the CAS was 60.3% in Tanggula and 63.8% in Lhasa. However, Ren et al[18] reported an AMS prevalence of 57.2% at 3600 m; and a lower rate (29.79%) was found by Chen et al[19] at 3200 m. Even when the same scoring system was used, the results still varied among these different studies. The results can be influenced by many factors, such as trial site, altitude, subjects (age, race, physical, and psychological condition), and so on. For example, according to the research of Tang Xugang and his team, among disparate ages, age was a risk factor for AMS at 3700 m.[22]

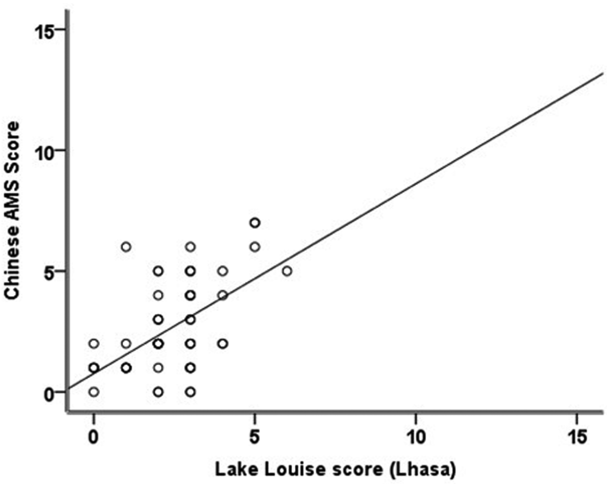

FIGURE 2. Correlation between the CAS and the LLS in the diagnosis of AMS in Lhasa. The solid line represents the fitting trend between the CAS and the LLS. Open circles represent the CAS and the LLS scores of each participant. rho = 0.50, tau = 0.43, $R^2 = 0.31$, Pearson = 0.56, and $P < 0.01$. AMS = acute mountain sickness, CAS = Chinese AMS score, LLS = Lake Louise score.

Although the prevalence determined in the present study differed from that found in previous work, past and present studies exhibit common tendency. The study of Luo et al[12] in 2009 indicated that 8.2% of subjects had AMS at Tanggula, compared with 14.3% upon arrival in Lhasa, as assessed by the LLS on the train. Many published reports indicate that AMS prevalence correlates positively with altitude and adapting to the plateau environment. Nevertheless, Luo et al's results and our experiment indicated that Lhasa, not Tanggula, had the highest AMS prevalence. This may be because the time required for train transport to Lhasa from Tanggula (8 h) is not very long, such that the transition time was too short for subjects' bodies to adapt to the decreasing altitude. However, after reaching Lhasa, their bodies became used to the hypoxia and the depressed environment on the plateau. Subsequently, with increasing adaptation time, the prevalence of AMS slowly declined.

The experimental data reported herein indicate that the trends of change in the 2 scoring methods was basically the same, but that the AMS prevalence determined by the CAS was higher than that determined by the LLS, which is similar to Chen et al's[19] findings. According to Figures 1 and 2, Pearson = 0.72 ($P < 0.01$) in Tanggula, and the CAS results were significantly correlated to the LLS results. In Lhasa, Pearson = 0.56 ($P < 0.01$), and the CAS and LLS results also were significantly correlated. However, the Kappa coefficients in the chi-square test were 0.40 ($P < 0.01$) in Tanggula and 0.32 ($P < 0.01$) in Lhasa, suggesting that alignment of the 2 types of testing methods was general or weak.

Moreover, validated by LLS diagnoses of AMS in Tanggula (Figure 4), ROC results indicated that the AUC was 0.865 (0.759–0.971; $P < 0.01$), indicating that the CAS was fairly accurate in determining AMS diagnoses. The best cut-off score for the CAS was 3.5 (Youden index was 0.667; sensitivity 76.5%; specificity 90.2%); it is the result as validated by LLS under this experimental condition and indicates that this point (sensitivity 76.5%, specificity 90.2%) is the most close to the top left corner of ROC. Meanwhile, the best cut-off score is close to the diagnostic criteria (headache +, vomiting +, or a total score of 5–10 is required to diagnose mild AMS). When the CAS score was 5, the sensitivity and specificity were 61.8% and 92.7%, respectively. Such high specificity and low sensitivity will increase the proportion of false-negative results. However, at the OOP, the sensitivity was 76.5%, indicating more accurate AMS diagnoses. In this regard, the nonspecific symptoms (headache and vomiting) of the CAS expand the conditions assessed for AMS diagnosis. In comparison, the LLS considers only 5 symptoms, whereas the CAS evaluates more specifically the body's response to the plateau environment. In the LLS diagnosis, a headache is a necessary symptom for AMS diagnosis, whereas the score must be ≥ 3. Although many people reported headache in Lhasa (35 [60.3%]), only 22 people scored ≥ 3. In the CAS diagnosis, headache and vomiting did

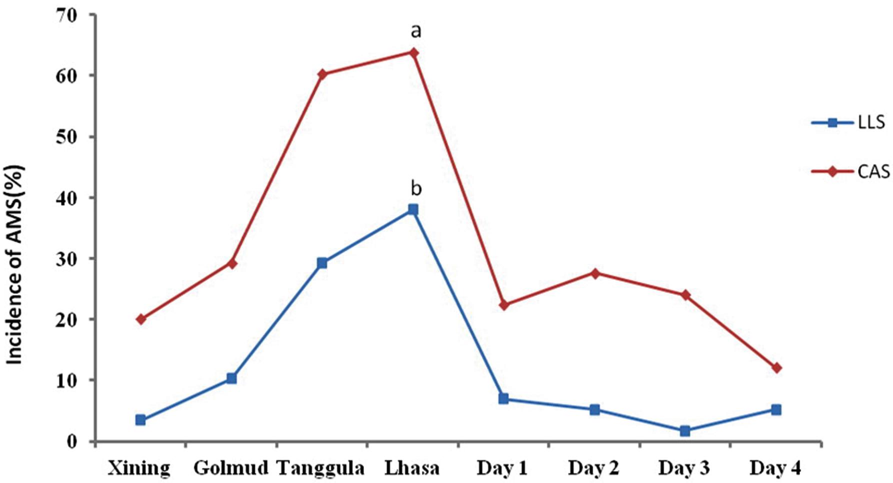

FIGURE 3. Relationship between prevalence rates determined by the CAS and the LLS. ([a]) $P<0.05$: compared with Golmud, Tanggula, and day 1, day 2, day 3, and day 4, as assessed by the CAS. ([b]) $P<0.05$: compared with Golmud, Tanggula, and day 1, day 2, day 3, and day 4, as assessed by the LLS. CAS = Chinese AMS score, LLS = Lake Louise score.

not constitute a premise index for AMS, but served solely as diagnostic criteria. Thus, when using the CAS to assess AMS in Lhasa, 37 (63.8%) people reported headaches, consistent with the AMS prevalence determined (also 63.8%). In general, in our experiment, the CAS seems capable of effectively diagnosing AMS as validated by LLS (sensitivity 61.8%, specificity 92.7%).

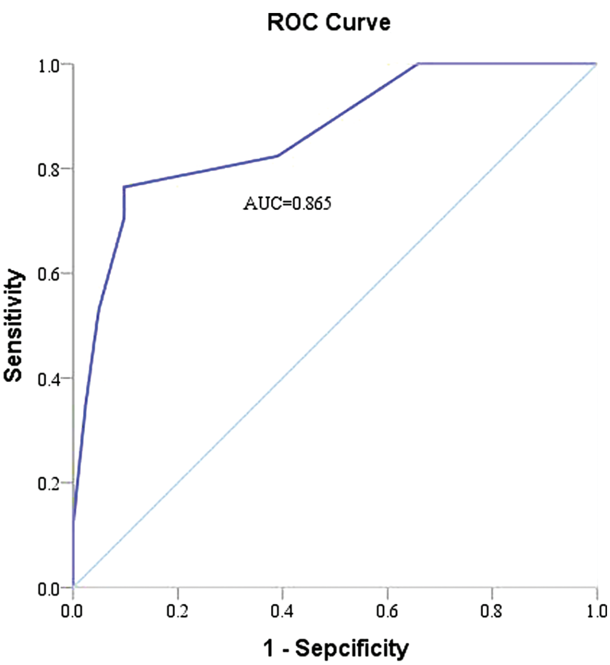

FIGURE 4. Diagnostic accuracy of the CAS. Receiver-operator curves for AMS diagnosis using the CAS. The area under the ROC curve (95% CI) was 0.865 (0.759–0.971; $P<0.01$), and the best cut-off score of CAS = 3.5 (Youden index was 0.667; sensitivity 76.5%; specificity 90.2%). AMS = acute mountain sickness, CAS = Chinese AMS score, CI = confidence interval, LLS = Lake Louise score.

The LLS has been widely utilized throughout the world as the gold standard scoring system for diagnosing AMS and has won the acceptance of many plateau medical researchers. The present article compares diagnoses obtained via the LLS and the CAS, and shows that the CAS can also fairly accurately diagnose AMS.

Finally, our research regarding the prevention of plateau diseases provides a practical reference, but some experimental limitations cannot be overlooked. Notably, the sample size for the experiment is small and taken from a single setting, such that the related results may not be applicable to other settings and populations. Future studies should broaden the population of subjects with regard to quantity, age, and sex so that the sample more objectively reflects the cases of AMS occurring in the plateau. Meanwhile, the causality between different diagnostic methodologies and disease outcomes with respect to treatment should be investigated. In addition, the self-reported scoring system is one of the major potential confounders in epidemiologic investigation; it will be affected by the subject's psychological condition and cognition, which can not make accurate judgment to his/her symptoms, especially the people with no previous high altitude experience.[18] We had made a detailed instruction on the 2 questionnaires and appropriate psychological counseling for participants before the start of the experiment, and took some measures to try to reduce the confounder during the experiment. But this confounder in the self-reported scoring system cannot be completely avoided, and it should be taken seriously in the similar research.

CONCLUSIONS

The Qinhai-Tibet railway is an important traffic artery in Tibet, and with the development of tourism and improvements in the economy, increasing numbers of people will travel to Tibet, which will lead to an increase in incidences of plateau diseases. In conclusion, our study compared AMS diagnoses obtained via the CAS and the LLS. The data indicate that the 2 score systems changed along similar trends with altitude, but that the prevalence of AMS determined by the CAS was higher than that determined by the LLS. Based on statistical analysis, the AUC was 0.865 (0.759–0.971; $P < 0.01$), Youden index was 0.667, the sensitivity was 76.5%, and the specificity was 90.2%, demonstrating that the CAS can fairly accurately diagnose AMS as validated by LLS. Therefore, this study indicates plateau disease diagnosis with a practical reference value. We suggest combining the LLS and the CAS in applications of clinical diagnosis so that the occurrence of AMS is more objectively determined.

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