Neurología. 2011;**26(6)**:337-342

NEUROLOGÍA

www.elsevier.es/neurologia

ORIGINAL ARTICLE

Metric properties of the Spanish version of the Lake Louise Acute Mountain Sickness Questionnaire

F.J. Carod-Artal, [a,*] **D. Ezpeleta Echávarri,** [b] **A.L. Guerrero Peral** [c]

[a] *Servicio de Neurología, Hospital Virgen de la Luz, Cuenca, Spain*
[b] *Servicio de Neurología, Hospital General Universitario Gregorio Marañón, Madrid, Spain*
[c] *Servicio de Neurología, Hospital Clínico Universitario de Valladolid, Valladolid, Spain*

Received on 30th July 2010; accepted on 13th December 2010

KEYWORDS
Metric attributes;
Migraine;
Internal consistency;
Lake Louise Questionnaire;
Mountain sickness;
Validity

Abstract
Objectives: To assess the metric properties of the Lake Louise Acute Mountain Sickness (LLAMSQ) five-item questionnaire.
Methods: At the end of the course "Neuroscience in pre-Columbian Andean cultures" (Peru, 2009), the participants answered the self-reported version of the LLAMSQ. The following psychometric attributes were explored: acceptability (observed versus possible scores; floor and ceiling effects), scaling assumptions (item-total correlation >0.30), internal consistency (Cronbach¿s alpha), precision (standard error of measurement), and convergent and discriminative validity. Differences in mean score of LLAMSQ between symptomatic acute mountain sickness subjects and asymptomatic ones were calculated.
Results: The participants stayed for days at Cuzco (3,400 meters above sea level, MASL), Sacred valley (2,850 MASL) and Machu Picchu (2,450 MASL). Seventy people (60%males; mean age 50±8 years; 88.6%neurologists) were included in the study. LLAMSQ mean score was 3.36±2.02 (median 3; skewness 0.61). Ceiling and floor effects were 7.3% and 1.4%, respectively. Cronbach¿s alpha was 0.61, and standard error of measurement 1.26. LLAMSQ mean score significantly correlated (r=0.41, *P*=.002) with physical items (ataxia, dyspnoea, tremor, mental symptoms). LLAMSQ mean scores were significantly higher (worse) in those subjects who presented with acute sickness mountain (5.8 vs 3.0; Mann-Whitney, *P*<.0001).
Conclusions: Metric properties of the LLASMQ Spanish version are adequate. This questionnaire seems to be useful in the early detection of high-altitude illness.

* Corresponding author.
E-mail: fjcarod-artal@hotmail.com (F.J. Carod-Artal).

PALABRAS CLAVE
Atributos métricos;
Cefalea;
Consistencia interna;
Cuestionario Lago Louise;
Mal de altura;
Validez

Propiedades métricas de la versión española del Cuestionario de Mal de Altura del Lago Louise

Resumen
Objetivos: Evaluar las propiedades métricas de la versión española del Cuestionario de Mal de Altura del Lago Louise (CMALL) autoaplicado de 5 ítems.
Métodos: Tras el curso-seminario «Neurociencia en las culturas andinas precolombinas» (Perú, 2009), se entregó una encuesta a los participantes que incluía el CMALL. Se evaluó la aceptabilidad de los ítems (puntuaciones observadas vs valores posibles, efectos techo y suelo), asunciones escalares (correlación ítem-total > 0,30), consistencia interna (alfa de Cronbach), precisión (error estándar de la medida) y validez de convergencia y discriminante. Esta última se evaluó calculando el valor medio del CMALL entre aquellos neurólogos que creían haber presentado mal de altura frente a quienes no lo habían presentado.
Resultados: Estancia por días en altura: Cuzco 3.400 m sobre el nivel del mar (msnm), Valle Sagrado (2.850 msnm) y Machu Picchu (2.450 msnm). Se incluyeron 70 sujetos (60% varones, edad media 50 ± 8 años, 88,6%neurólogos). El valor medio del CMALL fue 3,36 ± 2,02 (mediana 3, asimetría 0,61). Los efectos techo y suelo fueron 7,3 y 1,4% El alfa de Cronbach fue 0,61 y el error estándar de la medida 1,26. El CMALL se correlacionó significativamente (r = 0,41, p = 0,002) con los ítems de exploración física (ataxia, disnea, temblor, síntomas mentales). Las puntuaciones del CMALL fueron significativamente mayores (peores) en quienes presentaron mal de altura (5,8 vs 3,0; Mann-Whitney, p < 0,0001).
Conclusiones: Las propiedades métricas de la versión española del CMALL parecen ser adecuadas. Este cuestionario puede ser útil en la detección precoz del mal de altura.

Introduction

Exposure to altitude in subjects who are not acclimatised can cause acute mountain sickness, characterised by a combination of signs and symptoms, many of them of a neurological nature, where headache is the main symptom.[1] Insomnia, fatigue, feeling of dizziness and instability, anorexia and nausea are also common.[2,3] The most serious forms of acute mountain sickness can cause high altitude cerebral oedema. In symptomatic subjects, there is usually a certain individual susceptibility, as well as a lack of prior acclimatisation.[4]

Some people can sometimes present high altitude headache, where the headache occurs above 2,500m and cannot be attributed to any other cause.[5] The diagnostic criteria for altitude headache according to the second edition *International Headache Society*[6] classification are summarised in table 1.

There are currently no adapted questionnaires in Spain to assess acute mountain sickness. The aim of this study was to analyse the metric properties of the Spanish version of the Lake Louise Acute Mountain Sickness (LLAMSQ) five-item self-reported Questionnaire, which is the most commonly known and used questionnaire for detecting acute mountain sickness.[7] The direct application of the English version of the questionnaire, with no prior adaptation to other languages or cultural contexts, can cause diagnostic failures.[8]

There are other more complex questionnaires that assess acute mountain sickness, such as the *Environmental Symptoms Questionnaire (ESQ),* consisting of 67 items with Acute Mountain Sickness subscales and Respiratory Symptoms.[9,10] Unlike these more complex questionnaires, the LLAMSQ can be quickly applied to clinical practice. The scores obtained are useful for screening by health personnel in a rescue process or to make treatment and evacuation decisions high in the mountains.

Methods

Participants

The individuals included in the study were participants in a neurological history seminar-course "Neuroscience in Pre-Columbian Andean Cultures" held in Peru during February 2009. Once the course was completed, the participants were handed a survey that collected socio-demographic data, pathological history, as well as the LLAMSQ and Headache at High Altitudes Questionnaire.

Lake Louise Acute Mountain Sickness Questionnaire

The Lake Louise AMS scoring system was made up of 2 sections, a questionnaire on symptoms and a section for clinical examination.[7]

Table 1 Diagnostic criteria for altitude headache

A.	Headache with at least 2 of the following characteristics and that complies with criteria C and D:
	1. Bilateral
	2. Frontal or fronto-temporal
	3. Dull or oppressive quality
	4. Mild to moderate intensity
	5. Is aggravated by exercise, movement, effort, coughing or when bending over
B.	Ascent to an altitude above 2,500m
C.	The headache develops during the first 24hrs of the ascent
D.	The headache goes away in the first 8hrs after the descent

The symptoms questionnaire comprised 5 items on which the participants themselves could respond: Headache, Nausea and vomiting, Fatigue/tiredness, Dizziness/confusion and Sleep Disorders (table 2). The total score of the questionnaire was 15 points and could be clinically useful when diagnosing and monitoring the symptoms of acute mountain sickness in people exposed to it.

Table 2 Individual items on the self-reporting Lake Louise Acute Mountain Sickness Questionnaire

Headache	
No headache	0
Mild headache	1
Moderate headache	2
Severe, incapacitating headache	3
Nausea and vomiting	
No nausea and vomiting	0
Anorexia or mild nausea	1
Moderately intense nausea and/or vomiting	2
Serious nausea and/or vomiting	3
Fatigue/tiredness	
No fatigue or tiredness	0
Mild fatigue or tiredness	1
Moderately intense fatigue or tiredness	2
Serious fatigue or tiredness	3
Dizziness/confusion	
No dizziness	0
Mild dizziness	1
Moderate dizziness	2
Severe, incapacitating dizziness	3
Sleep disorders	
None	0
I haven't slept as well as usual	1
I woke up several times; I've slept badly	2
I've hardly been able to sleep at all	3

Table 3 Assessment system for the self-reporting Lake Louise Acute Mountain Sickness Questionnaire

Clinical assessment	
A. Changes in mental state	
No changes in mental state	0
Lethargy	1
Disorientation or confusion	2
Stupor or unconsciousness	3
B. Ataxia	
No ataxia	0
Carries out manoeuvres to maintain balance	1
Falls to the floor	2
Cannot remain standing	3
C. *Peripheral oedema*	0
No peripheral oedema	1
Peripheral oedema in one place	2
Peripheral oedema in two or more places	3
Functional score	
Overall, if you have had any symptoms, how much did it affect your activities?	
No reduction in activities	0
Slight reduction in activities	1
Moderate reduction in activities	2
Severe reduction in activities	3

Acute Mountain Sickness diagnosis is primarily based on the presence of a main symptom, the headache —even if mild—which is associated to a stay at high altitude over the previous few days with the presence of at least one extra symptom and a score of 3 or more in the questionnaire. A score of 3 to 5 shows mild acute mountain sickness and a score of 6 or more shows severe acute mountain sickness.

The questionnaire of symptoms can be carried out via a clinical interview, or more commonly with a self-reported one. The self-reporting version of LLAMSQ adapted to Spanish was the subject of this study, with later psychometric analysis. The scale was adapted and translated (English-Spanish) by the authors in search of a better semantic adaptation with the purpose of making a correct application of it without inducing comprehension errors in the items used.

The second part of the assessment system (a clinical examination that can be carried out by individuals on their own, but that is normally carried out by trained health staff) is useful to identify the progress of acute mountain sickness towards altitude cerebral oedema after mental state, ataxia and presence of peripheral oedema is assessed. This part includes a functional score that assesses the impact of any symptom on everyday life activities (table 3).

Psychometric analysis

The following metric properties for LLAMSQ were assessed: quality of the data and acceptability of the items, scaling assumptions, reliability, precision and validity.[11] We will briefly explain below what these metric properties are comprised of.

Acceptability is the metric property that analyses if the distribution of the scores in a scale represents the real distribution of the state of health or disease of the sample. Acceptability was assessed through distribution analysis and a score range, scores observed vs possible LLAMSQ values and floor and ceiling effects. The last terms refer to the percentage of individuals that score in extreme LLAMSQ values (minimum and maximum score obtained respectively, which should be less than 15%).[12]

Scaling assumptions refer to checking the correct grouping of the items in the LLAMSQ. They also assess if the sum of the 5 items is appropriate to produce the total score of the construct "suffering from acute mountain sickness," which we are trying to measure. Scaling assumptions are checked via the total corrected item-score correlation, avoiding the inclusion of the item itself in the total. The total corrected LLAMSQ item-score should be greater than or equal to 0.30[13] (Spearman's correlation coefficient).

Reliability is the property indicating that the questionnaire is free from random error. Internal consistency, together with reproducibility, is a fundamental feature of this metric attribute. The internal consistency of LLAMSQ was assessed using Cronbach's alpha. An acceptable internal consistency was considered as values above 0.7.[14]

Precision refers to the ability of the questionnaire to detect small differences. This metric attribute is expressed in a standard measurement error form, which is calculated with the following formula: standard error of the measurement=standard deviation x $\sqrt{}$(1-reliability coefficient).[15]

The validity of the external construct refers to the combination of strategies used to establish validity of a measurement instrument through a series of procedures that analyse the relationship of the score obtained with other similar ones. For this, convergent validity and discriminative validity have to be determined at the same time.[16]

Convergent validity is the level to which a scale correlates with the results obtained with other measurements for the same construct.[17] For this, we calculated Spearman's correlation coefficient (r_S) between the mean LLAMSQ score with a set of self-reporting items created by the authors (table 4: Mental symptoms, ataxia, dyspnoea and tremor), which were assessed at the same time as the acute mountain sickness scale was applied. The *a priori* hypotheses established was that these correlations with the neurological self-examining items would be moderate (r_S=0.30-0.59).

Discriminative validity refers to the capacity of the measurement instrument (LLAMSQ) to detect differences at a point in time between groups that are different in other measurements. Discriminative validity was assessed calculating the mean LLAMSQ score between those neurologists who thought they had presented acute mountain sickness against those who reported not having had it. The 2 questions used were the following: Do you think you have suffered from acute mountain sickness? Do you think you have partially suffered from acute mountain sickness? The mean scores obtained in the LLAMSQ in both groups were compared using the Mann-Whitney U test.

The statistical analysis was carried out using the SPSS 13.0 programme (SPSS, Chicago, IL).

Table 4 External clinical assessment items used to measure the convergent validity of the self-reporting Lake Louise Acute Mountain Sickness Questionnaire

Mental symptoms	
None	0
Mild attention disorder, slight slowness in thinking	1
Moderate bradypsychia, frequent disorientation	2
Inability to retain information, confusion, hallucinations	3
Ataxia	
None	0
Mild, with an occasional stumble or manual clumsiness	1
Moderate, with obvious clumsiness in walking or when using hands	2
Serious, needs help to walk or eat	3
Dyspnoea	
No respiratory difficulty	0
Dyspnoea with moderate exercise (going up a hill)	1
Dyspnoea with slight exercise (walking on the level)	2
Resting dyspnoea	3
Tremor	
None	0
Slight tremor (makes signing difficult or conditions it)	1
Moderate tremor (makes using cutlery difficult)	2
Serious tremor (incapacitating)	3

Results

Seventy Caucasian Spanish people, who had not previously lived in geographical regions of altitude, took part in the study. The mean altitude they normally lived at was 409.7m above sea level. There was a percentage of 60% who were male, a mean age of 50±8 years and 88.6% of the participants were neurologists. Their mean weight was 74.4±15.2kg and mean height was 170.3±8.7cm. There was a 31% percentage rate of participants who presented migraine and 15.7% smoked. There were no people who had active or symptomatic pulmonary disease.

The questionnaire was carried out after the course had finished. Of the subjects, 16% recognised having suffered from acute mountain sickness and 36.2% a partial form of it. The first 2 days of the course took place in Lima, at sea level. The stay in altitude over the next days was as follows: Cuzco (2 days and 2 nights), 3,400 metres above sea level (MASL); Valle Sagrado (a day and a night), 2,850 MASL; and Machu Picchu (a day), 2,450 MASL. The physical activity carried out during the stay on the neurological history course was moderate, the participants did not undertake mountain crossings and they had no previous exposure to moderate or high altitudes.

The LLAMSQ mean score was 3.36±2.02 (median, 3; skewness, 0.61). The range of values observed swung from

0 to 10 (possible range: 0-15). The floor and ceiling effects were 7.3 and 1.4% respectively.

The corrected item-total correlation (Spearman coefficient) was: 0.27 (sleep item), 0.33 (dizziness item), 0.34 (nausea item), 0.39 (headache item) and 0.57 (tiredness item). The Cronbach alpha score was 0.61 and the standard error of the measurement, 1.26. The elimination of item 5 (sleep) improved the Cronbach alpha score by 0.63.

With relation to the convergent validity, the LLAMSQ correlated significantly with the items of physical self-examination: ataxia, dyspnoea, tremor and mental symptoms ($r=0.41$; $P=0.002$). The correlation between the dyspnoea and tiredness items was significant ($r=0.39$).

The discriminative validity was appropriate. The scores obtained in the LLAMSQ were significantly greater (worse) in the group of neurologists that responded having suffered from acute mountain sickness (5.8 points vs 3.0 points; Mann-Whitney U, $P<0.0001$).

Discussion

We present the metric properties of the Spanish LLAMSQ version. The authors have not found a psychometric analysis process and standardised validation in medical literature, in accordance to the modern psychometric theories, of the original English version. The LLAMSQ adaptation was carried out in a group of neurologists exposed to altitude with no previous acclimatisation. The sample could be representative of a group of middle-aged individuals who travel to areas of high altitude with no previous acclimatisation and not for sporting reasons. The application of LLAMSQ in children and adolescents can underestimate the symptoms of acute mountain sickness.[18]

The percentage of scores in the extreme values of the scale (floor and ceiling effects) was small in LLAMSQ. There were no high values in the scale because there were no serious cases of acute mountain sickness and there was no exposure to altitudes of more than 4,000m.

The internal consistency found, according to Cronbach's alpha, was moderate (0.63). This is partly explained because the value of Cronbach's alpha is dependent on a number of items comprising a scale and decrease as their number in the scale or category is reduced. In a study of miners who were exposed to altitude in Chile, the Cronbach alpha value of LLAMSQ was 0.70.[19]

The scaling assumptions of the items were suitable and only the sleep item scored under 0.30. The tiredness item presented the best item-questionnaire correlation. The fact that it was a middle aged population, who did not practise physical activities regularly at high altitude, could have influenced the result. However, tiredness can be a sensitive clinical symptom that is frequently associated to acute mountain sickness. An important fact of the score system is that it emphasises the importance of headache in the definition of acute mountain sickness. The item-total correlation for the headache item was greater than the criteria established (0.39).

The standard error of the measurement was small. Therefore, the difference in a point that could be obtained from two different measurements on the scale could be due to the error of measurement from the questionnaire itself.

The LLAMSQ test also has suitable discriminative validity, given that the scores obtained show that the individuals in the sample who presented acute mountain sickness symptoms scored worse in this questionnaire. The convergent validity of the Spanish version of LLAMSQ seems to be equally correct.

However, this study presents some limitations. It was carried out among middle-aged people who were exposed to altitude without previous acclimatisation, the majority of whom were neurologists; this is why the generalisation of the findings for other population groups could be limited. The analysis for convergent validity with the items of self-reporting physical examination might not be extrapolative, as it deals with a trained sample, and the clinical assessment was carried out by the neurologists themselves subject to the trial. Despite being able to assess whether they presented symptoms of acute mountain sickness, an external clinical assessment to establish the diagnosis of acute mountain sickness would have been advisable. As the acute mountain sickness symptoms were not very severe, no self-reporting variables were used, such as the percentage of oxygen saturation and the presence of cyanosis, for example. However, the analysis of known groups suggests the validity of the scale.

The variability of the data obtained in our sample is limited, as the majority of the individuals scored in the lower two thirds of the scale. This is probably due to the fact that the exposure to altitude was moderate. This fact could hinder the assessment of the behaviour of the scale in individuals presenting more intense acute mountain sickness. However, the people in our study went from sea level altitude to an altitude of more than 3,500m without any previous acclimatisation. We believe that this change in altitude is indeed of value, mainly because the scale is directed at people who often expose themselves to a medium altitude without acclimatisation and not to an extreme altitude.

This study suggests that the Spanish version of LLAMSQ could be a suitable questionnaire to assess the symptoms of acute mountain sickness. The population in which the metric properties were assessed in the questionnaire was mainly composed of neurologists. This is why we recommend new psychometric studies that can analyse other metric properties (reproducibility, sensitivity to change), as well as their application to other selected reference groups (sport enthusiasts, mountaineers, young people and the elderly) by combining the use of other instruments to assess acute mountain sickness.[20, 21] In this type of studies, an external clinical examination for acute mountain sickness is recommended so as to be able to analyse sensitivity and specificity. To conclude, the metric properties of LLAMSQ seem to be suitable. This self-reporting questionnaire could be useful for the early detection of acute mountain sickness.

Conflict of interest

The authors have no conflict of interest to declare.

Acknowledgements

We are grateful to all the people who took part in the neurological history course "Neuroscience in Pre-Columbian Andean Cultures" held in Peru in 2009.

References

1. Hackett PH, Roach RC. High-altitude illness. N Engl J Med. 2001;345:107-14.
2. Silber E, Sonnenberg P, Collier DJ, Pollar AJ, Murdoch DR, Goadsby PJ. Clinical features of headache at altitude. A prospective study. Neurology. 2003;60:1167-71.
3. Wilson MH, Newman S, Imray CH. The cerebral effects of ascent to high altitudes. Lancet Neurol. 2009;8:175-91.
4. Pesce C, Leal C, Pinto H, González G, Maggiorini M, Schneider M, et al. Determinants of acute mountain sickness and success on Mount Aconcagua (6,962 m). High Alt Med Biol. 2005;6: 158-66.
5. Serrano Dueñas M. High altitude headache. A prospective study of its clinical characteristics. Cephalalgia. 2005;25:1110-6.
6. Headache Classification Committee of the International Headache Society. The International Classification of Headache Disorders. 2nd edition. Cephalalgia. 2004;24 Suppl 1:S1-160.
7. Roach RC, Bartsch P, Hackett PH, Oelz O, the Lake Louise AMS Scoring Consensus committee. The Lake Louise Acute Mountain Sickness scoring system. In: Sutton JR, Houston CS, Coates G, editors. Hypoxia and Molecular Medicine. Burlington: Queen City Press; 1993. p. 273-4.
8. Dellasanta P, Gaillard S, Loutan L, Kayser B. Comparing questionnaires for the assessment of acute mountain sickness. High Alt Med Biol. 2007;8:184-91.
9. Sampson JB, Kobrick JL. The environmental symptoms questionnaire: revisions and new field data. Aviat Space Environ Med. 1980;51:872-7.
10. Sampson JB, Cymerman A, Burse RL, Maher JT, Rock PB. Procedures for the measurement of acute mountain sickness. Aviat Space Environ Med. 1983;54:1063-73.
11. Martínez-Martin P, Frades Payo B. Desarrollo de un instrumento de valoración de calidad de vida relacionada con la salud. In: Martínez-Martín P, editor. Calidad de vida en Neurología. Barcelona: Ars Medica; 2006. p. 33-48.
12. McHorney CA, Tarlov AR. Individual-patient monitoring in clinical practice:are available health surveys adequate? Qual Life Res. 1995;4:293-307.
13. In: Fayers PM, Machin D, editors. Quality of Life: Assessment, Analysis and Interpretation. Chichester: John Wiley & Sons; 2000.
14. Cronbach LJ. Coefficient alpha and the internal structure of tests. Psychometrika. 1951;16:297-334.
15. Scientific Advisory Committee of the Medical Outcomes Trust. Assessing health status and quality-of-life instruments: Attributes and review criteria. Qual Life Res. 2002;11:193-205.
16. Carod-Artal FJ, González-Gutiérrez JL, Egido-Herrero JA, Varela de Seijas E. Propiedades métricas de la versión española del perfil de las consecuencias de la enfermedad de 30 ítems adaptado al ictus (SIP30-AI). Rev Neurol. 2007;45:647-54.
17. Nunnally JC, Bernstein IH. Psychometric theory. New York: McGraw-Hill; 1994.
18. Southard A, Niermeyer S, Yaron M. Language used in Lake Louise Scoring System underestimates symptoms of acute mountain sickness in 4- to 11-year-old children. High Alt Med Biol. 2007;8:124-30.
19. Vera A, Sepúlveda R, Contreras G. Auto-Reporte de Síntomas Físicos y Correlatos Psicosociales en Trabajadores de la Minería. Ciencia y Trabajo. 2006;8:74-8.
20. Wagner DR, Tatsugawa K, Parker D, Young TA. Reliability and utility of a visual analog scale for the assessment of acute mountain sickness. High Alt Med Biol. 2007;08:27-31.
21. Maggiorini M, Müller A, Hofstetter D, Bärtsch P, Oelz O. Assessment of acute mountain sickness by different score protocols in the Swiss Alps. Aviat Space Environ Med. 1998;69: 1186-92.