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Efficacy of spinal chiropractic manipulative therapy for adjusting the relationship between cervical facet joints to treat headache caused by acute mountain sickness

Yuan Wang[1]*, Mengzi Xu[2]* and Yan Shi[2]

Abstract

Objective: To investigate the effect of spinal chiropractic manipulative therapy (SCMT) on the management of acute mountain sickness (AMS)-induced headache.

Methods: One hundred individuals who traveled to Tibet between June and October 2015 were randomized to SCMT and standard AMS pain control groups. The primary endpoints were headache and vertigo improvement.

Results: There were 58 men and 42 women (mean age, 39.3 ± 11.1 years) with no significant differences in sex and age between the SCMT and control groups. However, a history of both headache and hypertension was higher in the controls. The two groups showed significantly improved visual analog scale (VAS) pain scores at 10 minutes, 30 minutes, and 24 hours after treatment compared with baseline. The SCMT group showed higher baseline VAS scores compared with controls, but lower VAS scores at 30 minutes. Improvements were also noted in dizziness, blood pressure, and oxygen saturation. There were no adverse events.

Conclusions: SCMT can be used to relieve AMS-induced headache, dizziness, blood pressure, and oxygen saturation of people traveling rapidly to high altitudes, but the symptoms were only evaluated for 24 hours. SCMT may be suitable for the management of AMS for patients who want to avoid drugs and oxygen inhalation.

[1]Department of Geriatrics, Beijing Geriatric Hospital, Beijing, China
[2]Department of Orthopedics, Beijing Haidian Hospital, Beijing, China

*These authors contributed equally to this work.

Corresponding author:
Yan Shi, Department of Orthopedics, Beijing Haidian Hospital, No. 29 Zhongguancun Street, Haidian District, Beijing 100080, China.
Email: shiyanrock@163.com

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Keywords
Spinal chiropractic manipulative therapy, chiropractic, spinal manipulation, acute mountain sickness, altitude, cervical facet joint disorder

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Introduction

The plateau area of China is vast, and about 1/6 of the country is 3000 m above sea level. The plateau area has the characteristics of low air pressure and a hypoxic environment. When plain dwellers arrive on the plateau rapidly, at an altitude >3000 m, they suffer from dizziness, headache, nausea, vomiting, and other clinical syndromes due to altitude hypoxia, which is called acute mountain sickness (AMS).[1–4] The incidence of AMS varies from 3% to 93% depending upon altitudes, occupations, populations, and individual differences.[5–7] AMS seriously affects the normal life and work of the people who have to come to areas such as Tibet, causing fear and anxiety in many people who have never visited the plateau, directly restricting them from traveling, investing, and working in Tibet. Furthermore, the condition may be serious because it may lead to pulmonary and cerebral edema in 0.1% to 4.0% of individuals.[4] At present, prevention is the main clinical focus of AMS management and includes hypoxic preconditioning, step adaptation, physical exercise, instrument aid, and drugs.[1–4]

High altitude headache is a chief concern among individuals visiting high altitudes; it develops within 24 hours of ascent and is worse at night and with exertion.[2] Mechanical strain on cervical structures such as the facet joints may aggravate joint arthrosis or disc degeneration and aggravate headaches due to hypoxia, as observed in divers, and with a mechanism similar to that of AMS.[8,9] Adjusting the relationship between cervical facet joints by spinal chiropractic manipulative therapy (SCMT) can correct small joint disorders caused by intervertebral instability.[10,11] This technique has achieved good results in the treatment of cervical vertigo disease and cervicogenic headache.[12,13] SCMT has the characteristics of being simple to perform, having a quick effect, being non-invasive, and causing no trauma.[11] SCMT can be used to correct cervical instability states including cervical facet joint disorders and slight dislocation of the cervical vertebrae, restore the internal balance of the cervical vertebrae and the normal anatomical position of the cervical vertebrae, relieve compression on the vertebral artery or relieve the angiospasm through the neural reflex mechanism, promote the regression of the local aseptic inflammatory edema of the soft tissue and the absorption of metabolites, and improve the blood circulation of the vertebral artery and cerebral blood supply, thus effectively relieving or alleviating the clinical symptoms of patients.[11,14,15] It is hypothesized that SCMT can alleviate AMS-induced headaches by improving cervical stability. Therefore, the aim of the present prospective trial was to investigate the effect of SCMT on the management of AMS-induced headache.

Materials and methods

Ethical statement

This trial was approved by the ethics committee of the Lhasa People's Hospital

(SYLL2115002). Each participant provided written informed consent.

Study design and subjects

This was a randomized controlled trial of individuals who flew from plain areas of mainland China (within half a day) or traveled by trains (within 2–3 days) to Tibet (Lhasa) between June and October 2015.

The diagnosis of AMS was based on a Lake Louise score of ≥ 3.[16] The Lake Louise score is based on the presence of: 1) fatigue or weakness; 2) dizziness or lightheadedness; 3) gastrointestinal symptoms such as nausea, vomiting, and anorexia; and 4) difficulty sleeping.

The inclusion criteria were: 1) birthplace in the plains; 2) perennial residence altitude ≤ 900 meters; 3) first time ever in Tibet; 4) diagnosis of AMS; 5) no history of specific diseases; 6) no cardiovascular or cerebrovascular diseases; and 7) general good health according to the results of various physical examinations. The exclusion criteria were: 1) AMS without severe headache or dizziness; 2) history of severe cardiovascular or cerebrovascular diseases; 3) used oxygen inhalation, Chinese or western medicine, or other drugs; 4) history of cervical surgery; or 5) diagnosis of cervical spondylopathy.

Randomization and blinding

The subjects were randomly divided into an SCMT group and a control group, comprising subjects who used standard AMS pain control techniques. The randomization sequence was prepared by an independent statistician. The envelopes were opened sequentially by the therapist after the subject consented. Because of the nature of the intervention, the subjects and the therapist could not be blinded, but the evaluators were blinded.

Interventions

The treatments were carried out within 72 hours after the initial onset of symptoms in Tibet. The treatment effects were evaluated at 10 minutes, 30 minutes, and 24 hours after treatment. Treatment and evaluation were conducted at the Orthopedics Department of Lhasa People's Hospital. The subjects in the SCMT group received only SCMT (no drugs or oxygen). The position of the cervical facet joints was examined, and the position of the small joint of the cervical spine was adjusted by SCMT.[11,14,17,18] All patients were treated by the same doctor (with over 5 years of working experience). The patients were treated with SCMT for cervical atlantooccipital and atlantoaxial joint reduction. Taking the right side reduction as an example, the patient was seated, the left shoulder was fixed, and the front direction was adjusted to the left direction. After finding the right contact point and transverse process of the right atlas, the head was bent to the right. The doctor stood behind the patient in a slightly rightward direction. The right hand was parallel to the forearm, and the right palm was upward. The distal segment of the right thumb was placed on the anterior outer edge of the transverse process, and the proximal segment of the right thumb and the proximal segment of the index finger followed the thumb and were placed on the right transverse process. The left stabilizer's thenar was placed on the unadjusted side (left) to support the left mastoid and transverse processes. Atlas forward, thrust backward; atlas right, thrust left; atlas upward, with a little clockwise torsion; atlas right anterior rotation, and with force the head was turned right backward and down. Symptom relief and vital signs were assessed 10 minutes, 30 minutes, and 24 hours after treatment.

The subjects in the control group received standard treatments for AMS,

including oxygen inhalation through a nasal tube for 2 hours at 5 L/minute, oral ibuprofen 0.3 g twice daily for 2 days, and 250 mL of 5% glucose intravenously. Symptom relief and vital signs were assessed 10 minutes, 30 minutes, and 24 hours after treatment. Acetazolamide is not approved for the treatment of AMS in China.

Endpoints

The primary endpoint was the improvement of headache and vertigo symptoms. The secondary endpoints were the occurrence and improvement of other AMS symptoms and the occurrence of adverse reactions such as symptom aggravation or nerve damage and other conditions.

Efficacy assessment

The vital signs and changes in blood pressure, heart rate, and blood oxygen saturation were observed before and after treatment. The changes in the visual analog scale (VAS) pain index were observed before and after treatment.[19] The symptoms and functional score changes of cervical vertigo were observed before and after treatment. Dizziness was assessed using the Evaluation Scale for Cervical Vertigo.[20] This scale comprises five scales (vertigo, neck and shoulder pain, headache, activities of daily living, and psychological and social adaptation). Each question is rated from 0 to 4, and the total score is 30. Higher scores indicate less dizziness.

Sample size

The sample size could not be calculated because there is no literature, to our knowledge, on the treatment of AMS with SCMT, and no preliminary data. This was an exploratory experiment, and the sample size was arbitrarily set at 50 per group.

Statistical analysis

SPSS 23.0 (IBM, Armonk, NY, USA) was used to analyze the data. The continuous data were expressed as means ± standard deviation and analyzed using the Student t-test. The categorical data were expressed as rates (%) and analyzed using the chi-square test. ANOVA was used to compare the VAS before and after treatment between the two groups. Differences with a $P < 0.05$ were considered statistically significant.

Results

Characteristics of the subjects

There were 100 cases in this study (50 in the control group and 50 in the SCMT group), including 58 men and 42 women, ranging from 21 to 68 (39.3 ± 11.1) years old. There was no significant difference in sex and age between the two groups ($P > 0.05$), as shown in Table 1, but there were differences in transportation means into Tibet, history of headache, systolic blood pressure, and hypertension at altitude.

Effect of SCMT on headache, dizziness, and physiological parameters

The two groups showed significantly improved VAS scores at 10 minutes, 30 minutes, and 24 hours after treatment compared with baseline (all $P < 0.05$). The SCMT group showed higher baseline VAS scores compared with the control group ($P = 0.04$), but greater changes from baseline compared with the control group (all $P < 0.001$), strongly suggesting the efficacy of SCMT in treating AMS-induced headache. The scores of dizziness symptoms were significantly improved in the two groups compared with baseline ($P < 0.05$), but there was no difference in the score of

Table 1. General characteristics of the subjects.

n	SCMT 50	Control 50	P
Age (years)	39.5±11.0	39.1±11.4	0.892
Sex (male/female)	30/20	28/22	0.685
Transport into Tibet			0.001
Airplane	42	25	
Train	8	25	
Stay at high altitude (days)	0 (0,11)	1 (0,3)	0.841
Lake Louise Score			0.317
3–4	8	12	
≥5	42	38	
SBP	131.7 ± 17.8	128.5 ± 12.5	0.009
DBP	89.2 ± 13.0	86.6 ± 11.1	0.280
Duration of headache (hours)	30.0 ± 6.2	27.4 ± 2.9	0.069
History of headache	0	6 (12%)	0.012
Hypertension at altitude	0	6 (12%)	0.012
SPO_2	77.1 ± 6.0	80.3 ± 5.3	0.267
HR (beats/minute)	96.9 ± 12.7	101.6 ± 10.3	0.228

Continuous data are shown as mean ± standard deviation.
SCMT: spinal chiropractic manipulative therapy; SBP: systolic blood pressure; DBP: diastolic blood pressure. SPO_2: oxygen saturation; HR: heart rate.

dizziness symptoms after treatment ($P = 0.935$) (Table 2).

The systolic and diastolic blood pressures were significantly improved in both groups (all $P < 0.05$). In the SCMT group, the change in systolic blood pressure from baseline was significant at 10 minutes compared with the control group ($P = 0.003$), but was not different at 30 minutes and 24 hours (all $P > 0.05$). The change in heart rate was less important in the SCMT group at 30 minutes and 24 hours compared with the control group ($P = 0.050$ and $P = 0.002$) (Table 2).

SpO_2 was improved in both groups after treatment (all $P < 0.05$). Controls had a better SpO_2 than the subjects in the SCMT group at 30 minutes ($P = 0.01$).

Discussion

We postulate that, as with divers, mechanical strain on the cervical structures could aggravate headaches due to hypoxia.[8,9] SCMT can alleviate cervicogenic headache.[12,13] Therefore, the objective of the present study was to investigate the effect of SCMT on the management of AMS-induced headache. The results suggest that SCMT can be used to relieve AMS-induced headache, as well as dizziness symptoms, blood pressure abnormalities, and oxygen saturation of people traveling rapidly to high altitudes. The operation is convenient and is not limited by the need for special equipment. Therefore, SCMT is suitable for popularization and application for the management of AMS for patients who prefer to avoid the use of drugs or oxygen, but oxygen and analgesics remain an appropriate method to manage AMS. There is a possibility that the improvements in the two groups might be attributable to acclimation; this will have to be examined in future studies.

Some people entering Tibet for work or tourism suffer from AMS, including headache and dizziness, which can be

Table 2. Effect of treatment on headache, dizziness, and physiological parameters.

Groups	SCMT	Control	P
VAS score			
Before treatment	5.6 ± 1.6	2.7 ± 1.2	**0.035**
Change at 10 minutes after treatment	−3.73 ± 1.35	−0.16 ± 0.47	**<0.001**
Change at 30 minutes after treatment	−4.37 ± 1.37	−1.18 ± 0.60	**<0.001**
Change at 24 hours after treatment	−4.88 ± 1.54	−1.54 ± 0.93	**<0.001**
Symptom score of dizziness			
Before treatment	20.3 ± 4.4	24.1 ± 4.0	0.879
Change at after treatment	27.7 ± 3.0	27.4 ± 3.3	0.935
Systolic pressure (mmHg)			
Before treatment	131.7 ± 17.8	128.5 ± 12.5	**0.009**
Change at 10 minutes after treatment	−5.1 ± 7.1	−1.6 ± 3.9	**0.003**
Change at 30 minutes after treatment	−7.8 ± 6.9	−4.0 ± 5.6	0.403
Change at 24 hours after treatment	−8.6 ± 12.8	−5.9 ± 7.8	0.213
Diastolic pressure (mmHg)			
Before treatment	89.2 ± 13.0	86.6 ± 11.1	0.280
Change at 10 minutes after treatment	−3.2 ± 6.9	−2.7 ± 4.3	0.626
Change at 30 minutes after treatment	6.4 ± 6.2	−5.4 ± 5.4	0.403
Change at 24 hours after treatment	−6.7 ± 9.4	−6.0 ± 6.9	0.676
Heart rate (bpm)			
Before treatment	96.9 ± 12.7	101.6 ± 10.3	0.228
Change at 10 minutes after treatment	−4.4 ± 5.2	−4.8 ± 4.5	0.677
Change at 30 minutes after treatment	−6.2 ± 5.7	−8.7 ± 6.6	**0.050**
Change at 24 hours after treatment	−8.0 ± 7.0	−13.3 ± 9.3	**0.002**
SpO_2 (%)			
Before treatment	77.1 ± 6.0	80.3 ± 5.3	0.267
10 minutes after treatment	83.2 ± 5.0	84.3 ± 3.8	0.134
30 minutes after treatment	85.3 ± 3.3	87.5 ± 2.3	**0.010**
24 hours after treatment	86.9 ± 2.5	88.6 ± 2.7	0.727

Continuous data are shown as mean ± standard deviation.
SCMT: spinal chiropractic manipulative therapy; VAS: visual analog score; SpO_2: oxygen saturation.

inconvenient. It has been found that hypoxia can induce the release of excitatory amino acids, causing cytotoxic edema and cell necrosis.[21] However, activating nitric oxide synthase will lead to nitric oxide production and stimulation of the secretion of a large number of free radicals to enhance the sympathetic nerve activity and increase the hydrostatic pressure in the brain capillaries. Some studies have pointed out that brain edema is an important cause of intracranial hypertension in AMS.[22]

Based on the understanding of the mechanism of headache caused by AMS, the treatment of AMS-induced headache mainly include oxygen inhalation therapy (through a nasal tube for 2 hours at 5 L/minute) and drug therapy, and descent to lower altitudes for severe cases.[1–4] Acetazolamide and dexamethasone can be used in the management of AMS,[23–26] but they are not approved for such use in China. In the present study, the patients in the control group were treated with oxygen inhalation and analgesics, which are routinely used in front-line clinical practice. These strategies have some efficacy because the patients in the control group

showed improvements in VAS, dizziness, blood pressure, heart rate, and oxygen saturation. Indeed, oxygen inhalation can relieve pulmonary vasoconstriction, reduce pulmonary artery pressure, improve the anoxic state of the body, and achieve the purpose of etiological treatment.[27]

In the SCMT group, blood pressure, heart rate, VAS score, and oxygen saturation were significantly improved at 10 minutes, 30 minutes, and 24 hours after SCMT to adjust the cervical facet joints, which was statistically different from baseline. In addition, the subjects in the SCMT group had higher VAS at baseline but still achieved VAS scores lower than those of the control group, highlighting the efficacy of SCMT. This study found that adjusting the relationship between the facet joints of the cervical vertebrae by SCMT could relieve acute altitude reaction quickly and effectively. In the treatment group, the improvement of headache VAS score was better than that of the control group 10 minutes, 30 minutes, and 24 hours after treatment, and the improvement of the vertigo symptom score was significantly better than that of the control group. To our knowledge, no previous study has examined the efficacy of SCMT in managing AMS-induced headaches, and no direct comparison is possible. Studies of scuba divers, who are subjected to hypoxia episodes, show that mechanical strain on the cervical structures during diving might aggravate joint arthrosis or disc degeneration and thus aggravate headaches due to hypoxia.[8,9] In addition, SCMT has been reported to improve cervicogenic headaches.[12–15] Therefore, it is hypothesized that SCMT alleviates AMS-induced headaches by mechanisms that are independent of hypoxia. Additional study is necessary to examine this point.

AMS can be life-threatening.[28] As per the inclusion/exclusion criteria, the subjects were otherwise healthy before their ascent to the plateau, and their duration of stay was short. In addition, SCMT itself carries some risk of complications and injury,[29] but the subjects received only one treatment. This could explain, at least in part, why no serious adverse events occurred in this study. Furthermore, the Tibetan plateau is high but not so high as to cause serious AMS in all individuals or to lead to the necessity of taking medications for AMS. The control group was well controlled with analgesics and oxygen inhalation. Gradual ascent and the prophylactic use of acetazolamide should be emphasized in all individuals traveling to any high altitude.[28] Additional studies are necessary to address this issue.

The present study had limitations. Blinding was not possible. This was a pilot and proof-of-concept study, and a sham group will be considered in our future studies, according to the appropriate ethical principles. The project was carried out in Lhasa and included people working in Tibet and tourists. The flow of the research subjects was high. In addition, the groups were not well balanced at baseline (history of headache and hypertension). Furthermore, mid- and long-term follow-up could not be conducted in most patients because they were outpatients and travelers who spent a short time in Tibet, and the symptoms were evaluated for only 24 hours. SCMT is a type of physical therapy and does not require rigorous implementation conditions, nor does it require routine monitoring of blood and biochemical indicators.

The present study should be considered a pilot and proof-of-concept study. The results suggest that SCMT can be used to relieve AMS-induced headache, dizziness, blood pressure abnormalities, and oxygen saturation of people traveling rapidly to high altitudes, but the symptoms were only evaluated for 24 hours. The procedure is convenient and is not limited by the need

for special equipment. Therefore, SCMT may be suitable for popularization and application for the management of AMS for patients who prefer to avoid the use of drugs or oxygen, but oxygen and analgesics remain an appropriate method to manage AMS.

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Declaration of conflicting interest

The authors declare that there is no conflict of interest.

ORCID iD

Yan Shi https://orcid.org/0000-0002-0132-0829

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