Prevalence of depression and associated factors among Chinese military plateau drivers in Golmud, Qinghai Province, China: a cross-sectional study

Zhi-hao Tu
Second Military Medical University

Li Peng
Second Military Medical University

Jing-wen He
Second Military Medical University

Xing-hua Shen (✉ shenxhsci@sina.com )
Department of Nautical psychology, the Second Military Medical University, Shanghai, China

Research article

Keywords: High altitude, Chronic mountain sickness, Depression, Risk factors, Fatigue, Military personnel

DOI: https://doi.org/10.21203/rs.3.rs-34374/v1

License: ☑️ This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License
Abstract

**Background:** Depression is associated with declining duty performance, suicide and other serious problems in the army. Prolonged deployment at high altitude may result in depression among military personnel. The present study aimed to investigate the prevalence of depression among Chinese military plateau drivers and determine the associated factors.

**Methods:** The participants were military drivers selected from Golmud motor transport base (high altitude group) and Fuzhou motor transport base (low altitude group). All participants were asked to complete a self-administered questionnaire. The questionnaire included demographic and working characteristics, the Self Rating Depression Scale (SDS), the 14-item Fatigue Scale (FS-14), the Global Assessment of Migraine Severity (GAMS), the numeric rating scale (NRS) for dyspnea, and item three of the Patient Health Questionnaire-9-item (PHQ-9) for screening sleep disturbance.

**Results:** A total of 400 questionnaires were distributed (200 for each group); 400 questionnaires were collected (the response rate was 100%). After eliminating 16 invalid questionnaires, 194 plateau drivers and 190 lowland drivers provided valid response (96.0%). In comparison to lowland drivers, the plateau drivers had severer fatigue ($t = 4.298, \ p < 0.001$), severer migraine ($t = 11.440, \ p < 0.001$), severer breathlessness ($t = 12.094, \ p < 0.001$), severer sleep disturbance ($t = 3.353, \ p = 0.001$), and higher prevalence of depression symptoms ($\chi^2 = 15.123, \ p < 0.001$). The possibility of having depression symptoms was significantly higher among military plateau drivers who were suffering severer fatigue (OR = 1.14, 95% CI: 1.01-1.29), migraine (OR = 1.83, 95% CI: 1.13-2.95), breathlessness (OR = 1.69, 95% CI: 1.04-1.73), and sleep disturbance (OR = 1.78, 95% CI: 1.03-3.07).

**Conclusion:** Prevalence of depression was high among Chinese military plateau drivers. The risk factors were fatigue, severity of migraine, severity of breathlessness, and poor sleep quality. It is essential to become aware of these risk factors and their causes to intervene and help prevention of depression among Chinese military plateau drivers.

**Background**

China has more than 3000 kilometers of national borderline on the plateau, mostly on the Tibet plateau. For China, Tibet plateau is of great military strategic value. Chinese military plateau drivers station at Golmud motor transport base, Golmud (average altitude: 2,890 m), Qinghai Province. Their duty is to operate cargo carrying wheeled vehicles into Tibet (average altitude along the way: > 4100 m) to supply border posts with military material six times a year (lasting about 10 days per duty). According to China's military service system, these plateau drivers must serve there for at least 2 years. However, many of them choose to continue serving there for honor after two-year compulsory service period. The route into Tibet is full of difficulties and dangers, so completion of this transportation duty requires superb driving ability. In recent years, whether prolonged service at high altitude (HA) has an adverse effect on driving ability has been attracting more and more attention. However, most of the previous studies in this field
focused on the effect of chronic exposure to HA on cognitive functions [1, 2]. They often forgot that psychological distress, especially depression, also could influence driving safety [3, 4]. A meta-analysis study suggested that depression approximately double the risk of crash [3]. Bulmash et al. [4] found that depressed participants had significantly slower steering reaction time than healthy controls, which resulted in more crashes in driving simulator test. Besides driving safety, depression among military personnel was associated with many other serious problems, such as role disability and suicide [5, 6]. Actually, depression is one of the most alarming problem in any army all over the world [7, 8].

Due to the adverse consequences of depression, it is of great importance to investigate prevalence of depression and determining the related risk factors among military plateau drivers. As exposure to highly stressful working conditions, military personnel often suffer poorer mental health [9]. Compared with military personnel serving at low altitude (LA), military plateau drivers are continuously exposed to HA, a big environmental stressor for human being, which may cause both physiological and psychological dysfunction [10, 11]. Theoretically, military plateau drivers are more susceptible to depression. Unfortunately, very few previous studies focused on the relationship of HA deployment and depression among military personnel, which is also the case in the study of ordinary population. Gamboa et al. [12] found that the prevalence of depression was higher in men living at HA compared with those living at sea level. Bardwell et al. [10] found that Marines experienced enduring negative moods after 30-day high-altitude field training exercise. To our best knowledge, no published study reported prevalence of depression among military plateau drivers.

Abundant studies extensively investigated the influencing factors of depression among military personnel [13–15]. Gender, education, rank, social support, and insomnia were consistently associated with depression among military personnel in previous studies [15–17]. In addition to these common risk factors of depression, researchers argued that there may be a causal link between HA induced chronic mountain sickness (CMS) and depression [18]. CMS is a disease that develops after prolonged residence at HA, which is characterized by excessive erythrocytosis, hypoxemia, headache, breathlessness, sleep disturbances, physical and mental fatigue [12]. Interestingly, a study found that migraine (a main symptom of CMS) was positively associated with depression at HA [12]. The relationship of chronic fatigue and depression was also reported in many studies [19–21]. Thus, symptoms of CMS could also be risk factors of depression among plateau drivers.

In the present study, we aimed to investigate the prevalence of depression among Chinese military plateau drivers and determine the associated factors. Our findings can provide precious reference for both researchers and policy makers to decrease prevalence of depression among military plateau drivers and improve their driving performance.

**Methods**

**Study design and participants**
A cross-sectional study was conducted in Golmud (average altitude: 2,890m), Qinghai province and Fuzhou (average altitude: 84m), Fujian province, China during July and August 2016. 200 plateau drivers were selected from the Golmud motor transport base as HA group, and 200 drivers were selected from Fuzhou motor transport base as LA group. All selected drivers were male Han Chinese. Selected drivers with the following conditions were excluded: (1) suffering acute physical conditions; (2) born, growing or living at HA (> 500m) before enlisted; (3) for LA group, had gone to HA (> 500m) in the recent year; (4) for HA group, left the plateau in the recent 3 months. Self-administered questionnaires were directly distributed to the remained participants who were asked to complete the questionnaires in 15 minutes. Finally, 194 HA group participants and 190 LA group participants completed the questionnaires (see Fig. 1).

The protocols were approved by the Review Board of the Second Military Medical University. Written informed consent was obtained from each subject before participating in this study.

**Measures**

**Demographic and working characteristics**

Age, altitude, deployment duration at the present base, service time, educational level, marital status, only child or not, and military rank were obtained in this study. ‘Altitude’ was categorized as ‘High altitude’ and ‘Low altitude’. ‘Education’ was categorized as ‘Secondary school’, ‘High school’, ‘Junior college’, and ‘Undergraduate or above’. ‘Marital status’ was categorized as ‘Single’, ‘Married’. ‘Only child or not’ was categorized as ‘Yes’ and ‘No’. ‘Military rank’ was categorized as ‘Private’ and ‘Non-commissioned officer (NCO)’.

**Depression**

Depression was measured with the Self Rating Depression Scale (SDS) [22]. SDS consists of 20 items, and each item describes a symptom of depression scored on a four-point Likert scale according to the frequency of the symptoms in the previous week, with anchors 1 (none or a little of the time), 2 (some of the time), 3 (a good part of the time), 4 (most or all of the time). The total score was multiplied by 1.25 to obtain the standard score [23]. Higher standard score represented higher intensity of depression symptoms. According to the Chinese norm of the SDS, the severity of depression was calculated by dividing the total score by 80. The cut-off score was set at 0.5 in this study [24]. The Chinese version of SDS has been repeatedly validated and widely used to examine depression status among Chinese adults [24-26]. The Cronbach’s α of SDS in this study was 0.854.

**Symptoms of CMS**

Due to the time constraint, we measured four major symptoms of CMS in this study, namely fatigue, migraine, breathlessness, and sleep disturbances.
Fatigue was measured using 14-item Fatigue Scale (FS-14) [27]. The FS-14 consists of 14 yes-or-not questions (0 = no; 1 = yes) in order to reflect the severity of physical fatigue and mental fatigue. The total score was calculated and a higher score suggested severer fatigue. The Chinese version of FS-14 has been proved to have high reliability and widely used in China [28, 29].

Migraine was measured with Global Assessment of Migraine Severity (GAMS) [30]. GAMS contains a single question with seven response categories: “How severe is your migraine?”, 1 = Not at all severe, 2 = a little severe, 3 = somewhat severe, 4 = moderately severe, 5 = quite severe, 6 = very severe, 7 = extremely severe. GAMS has been proved to be a brief and valid tool to assess migraine severity [30].

Breathlessness was measured with numeric rating scale (NRS) [31]. NRS contains a single question “Are you short of breath now?” which is anchored at 0 and 10 with verbal anchors “nothing at all” to “maximal”. The NRS has been proved to be a valid measure of present dyspnea with low response bias [31, 32].

Sleep disturbance was measured with item three of the Patient Health Questionnaire-9-item (PHQ-9), which was an efficient brief screener for sleep disturbance with relatively high sensitivity and specificity [33]. The item asks the participant to rate how often he/she has had “Trouble falling or staying asleep, or sleeping too much” over the past two weeks, range from 0 (not at all) to 3 (nearly every day).

**Statistical analysis**

SPSS (version 22.0) was used for statistical analysis. All tests were two-tailed, and statistical significance level was set at a $p < 0.05$. HA group participants (plateau drivers) and LA (lowland drivers) were included in the analyses. Sociodemographic and working characteristics were recorded and reported as Mean ± SD for continuous variables and number (percentage) for categorical variables. Comparisons of depression, symptoms of CMS, and demographic data between HA and LA group were tested by independent sample t-tests and $\chi^2$ tests. Comparisons of depression and symptoms of CMS among different categorical demographic and working characteristics in HA group were tested by independent sample t-tests and ANOVA. Multivariate logistic regression was used to calculate the crude and adjusted odds ratio (OR) with 95% confidence interval (CI) to assess the factors associated with depression among plateau drivers.

**Results**

**Demographic and working characteristics**

Table 1 shows the demographic and working characteristics of HA group and LA group. Of the 194 HA group participants, 83.0% were non-commissioned officer, 75.8% were single, 60.8% had a high school diploma, and less than half were only child in the family. Average ages were 23.76 years (SD = 4.09, range = 18 - 35), and average deployment duration at Golmud was 61.71 (SD = 49.54. range = 4 - 192). Of the 190 LA group participants, 83.7% were non-commissioned officer, 78.9% were single, 63.7% had a
high school diploma, and 38.4% were only child in the family. Average ages were 23.64 years (SD = 3.89, range = 18 - 35), and average deployment duration at Golmud was 64.56 (SD = 48.38. range = 12 - 192). There were no significant difference of demographic and working characteristics between HA and LA group ($p > 0.05$), except deployment duration ($p = 0.002$).

**Prevalence of depression**

The prevalence of depression was 45.4% among HA group and 26.3% among LA group. The prevalence of depression among HA group was significantly higher than that among LA group ($\chi^2 = 15.123, p < 0.001$).

**Comparisons of symptoms of CMS**

As shown in Table 2, there was a significant difference in comparison of severity of fatigue ($t = 4.298, p < 0.001$), migraine ($t = 11.440, p < 0.001$), breathlessness ($t = 12.094, p < 0.001$), and sleep disturbance ($t = 3.353, p = 0.001$) between two groups. Thus, plateau drivers had severer fatigue, migraine, breathlessness, and sleep disturbance than lowland drivers.

**Factors associated with depression**

According to the results of a binary logistic model, the possibility of having depression symptoms was significantly higher among military plateau drivers who were suffering severer fatigue, migraine, breathlessness, and sleep disturbance (Table 2).

**Discussion**

Our data indicated that there was a relatively high prevalence of depression among Chinese military plateau drivers. To our best knowledge, this was the first study to investigate the prevalence of depression and associated factors among Chinese military plateau drivers.

As expected, prevalence of depression was higher among HA group than LA group. This result was in line with the previous study of Gamboa and his colleague [12]. A large sample survey showed that the prevalence of depression in Tibetans of the Qinghai–Tibet Plateau was higher than that in the general Chinese population [34]. Another study suggested that moving from LA to HA (>900m) was positively associated with higher prevalence of depression symptoms [35]. These results may indicate that there is a relationship between chronic exposure to HA and depression. HA-induced hypoxia may play an important role in this process. On one hand, chronic hypoxia can result in changes in dopamine and serotonin of the monoamine system [36, 37]. Dopamine and serotonin in turn play a critical role in the pathophysiology of depression [38, 39]. On the other hand, hypoxia-induced mitochondrial dysfunctions may also be associated with depression symptoms [40]. In addition, both harsh natural environment and monotonous social life on the plateau may have an adverse effect on mental health of plateau drivers [34].
In the present study, we found that migraine was more frequent and severer among HA group than LA group, and the severity of migraine was a risk factor of depression. Many previous studies have demonstrated the association between HA and migraine as well as the association between migraine and depression \[12, 41, 42\]. Gamboa et al. \[12\] also reported that there was an association between depression and migraine in HA population. Migraine as altitude increases may be result from cellular hypoxia due to decreased barometric pressure \[43\]. The relationship between migraine and depression may be bidirectional, and genes from serotonergic and dopaminergic may be associated with the aetiology of both migraine and depression \[42\]. In addition, chronic stress may also be a trigger that leads to migraine and depression \[44\].

The data indicated that HA participants got higher scores on FS-14 than LA participants, and FS-14 scores were associated with prevalence of depression among HA participants. Hypoxia may be the common factor which leads to fatigue and depression at HA \[45-47\]. Previous studies suggested that depression and chronic fatigue shared aberrations in inflammatory, oxidative, and nitrosative stress (IO&NS pathway \[48, 49\].

More serious breathless and sleep disturbance were reported in HA group than LA group, and both breathless and sleep disturbance were risk factors of depression. On one hand, higher prevalence of depression, breathless, and sleep disturbance were outcomes of hypoxia at HA \[50, 51\]. On the other hand, sleep disturbance and depression can influence each other and are reciprocal causation \[52\].

An unexpected result of this study was that there was no relationship between deployment duration at HA and prevalence of depression. Above all, we argued that longer residence at HA did make plateau drivers more susceptible to depression. However, this tendency was masked by other factors. First, adaptation to HA may be a protective factor. Abundant studies have found genetic and physiological changes for adaptation to HA among Tibetans on Qinghai-Tibet plateau \[53-55\]. Although, it is still unclear whether these adaptive process can also be observed among Han Chinese who migrate to Tibet plateau for service after adulthood, adaptation to HA do exist among these people. Military training may help military personnel acclimatized to HA \[56\]. Second, select-in and select-out of military personnel may also confound the result. According to China’s military service system, these plateau drivers must serve there for at least 2 years. After two-year compulsory service period, those who were not accustomed to HA can leave the army. But, if a plateau driver want to continue his service period and be promoted as a non-commissioned officer, he will receive rigorous tests. Only those who are the best can stay and be promoted. Thus, this survival bias may mask the association between deployment duration at HA and prevalence of depression. The same reason can explain why other demographic variable like age, educational level, military rank and marital status were not associated factors of depression in this study which were found to be associated factors in previous studies \[15-17\].

**Limitations**
This was a cross-sectional study, so it only can provide weak causal inference from chronic exposure to HA to higher prevalence of depression. Thus, future studies should include a longitudinal follow-up to determine the relationships between depression and other factors.

Conclusions

Depression is highly prevalent in Chinese military plateau drivers, with 45.4 % meeting the criteria for depression symptoms. Moreover, compared with military drivers at LA, Chinese military plateau drivers had higher severity of migraine, breathless, fatigue and sleep disturbance. In the present study, fatigue, severity of migraine, severity of breathlessness, and poor sleep quality were associated with high prevalence of depression among plateau drivers. It is essential to become aware of these risk factors and their causes to intervene and help prevention of depression among Chinese military plateau drivers.

Abbreviations

SDS: Self Rating Depression Scale; FS-14: 14-item Fatigue Scale; GAMS: Global Assessment of Migraine Severity; NRS: numeric rating scale; PHQ-9: Patient Health Questionnaire-9-item; OR: odds ratio; CI: confidence interval; HA: high altitude; LA: low altitude; CMS: Chronic Mountain Sickness

Declarations

Ethics approval and consent to participate

The protocols were approved by the Review Board of the Second Military Medical University. Written informed consent was obtained from each subject before participating in this study.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to the potential sensitive nature of military healthcare data.

Competing interests

The authors declare that they have no competing interests.

Funding

12th Five-Year Plan, Grant/Award Number: AWS12J002; People's Liberation Army, China

Authors' contributions
ZT, JH, and LP contributed equally to this work. LP and XH developed the study design. LP collected the data. LP, ZT and JH analyzed and interpreted the data. ZT and JH conducted a literature search and wrote the manuscript. All authors read and approved the final manuscript.

Acknowledgements

Thank a lot to my beloved wife and hard-working colleague: Jing-wen He.

References

1. Martin K, McLeod E, Périard J, Rattray B, Keegan R, Pyne DB. The Impact of Environmental Stress on Cognitive Performance: A Systematic Review. Hum Factors. 2019;61:1205–46.
2. Yan X. Cognitive impairments at high altitudes and adaptation. High Alt Med Biol. 2014;15:141–5.
3. Hill LL, Lauzon VL, Winbrock EL, Li G, Chihuri S, Lee KC. Depression, antidepressants and driving safety. Inj Epidemiol. 2017;4.
4. Bulmash EL, Moller HJ, Kayumov L, Shen J, Wang X, Shapiro CM. Psychomotor disturbance in depression: Assessment using a driving simulator paradigm. J Affect Disord. 2006;93:213–8.
5. Merikangas KR, Ames M, Cui L, Stang PE, Ustun TB, Von Korff M, et al. The impact of comorbidity of mental and physical conditions on role disability in the US adult household population. Arch Gen Psychiatry. 2007;64:1180–8.
6. LeardMann CA, Powell TM, Smith TC, Bell MR, Smith B, Boyko EJ, et al. Risk factors associated with suicide in current and former US military personnel. JAMA - J Am Med Assoc. 2013;310:496–506.
7. Gadermann AM, Engel CC, Naifeh JA, Nock MK, Petukhova M, Santiago PN, et al. Prevalence of DSM-IV Major Depression Among U.S. Military Personnel: Meta-Analysis and Simulation. Mil Med. 2012;177:47–59.
8. Tai Y-M, Gau SS-F. Depression and Quality of Life Mediating the Association Between Attention Deficit/Hyperactivity Disorder and Suicidality in Military Recruits. Mil Med. 2017;182:e1912–9.
9. Webb-Murphy JA, De La Rosa GM, Schmitz KJ, Vishnyak EJ, Raducha SC, Roeschet SC, et al. Operational Stress and Correlates of Mental Health Among Joint Task Force Guantanamo Bay Military Personnel. J Trauma Stress. 2015;28:499-504.
10. Bardwell WA, Ensign WY, Mills PJ. Negative mood endures after completion of high-altitude military training. Ann Behav Med. 2005;29:64–9.
11. Walsh NP, Whitham M. Exercising in Environmental Extremes. Sport Med. 2006;36:941–76.
12. Gamboa JL, Caceda R, Arregui A. Is depression the link between suicide and high altitude? High Alt Med Biol. 2011;12:403–4.
13. Woo SY, Kim HJ, Kim BR, Ahn HC, Jang BN, Park E-C. Support from superiors reduces depression in Republic of Korea military officers. BMJ Mil Heal. 2020;;jramc-2019-001343.
14. Nissen LR, Karstoft KI, Vedtofte MS, Nielsen ABS, Osler M, Mortensen EL, et al. Low-level cognitive ability in young adulthood and other risk factors of depression in an observational cohort study
15. Nazarov A, Fikretoglu D, Liu A, Thompson M, Zamorski MA. Greater prevalence of post-traumatic stress disorder and depression in deployed Canadian Armed Forces personnel at risk for moral injury. Acta Psychiatr Scand. 2018;137:342–54.

16. Bramoweth AD, Germain A. Deployment-related insomnia in military personnel and veterans topical collection on sleep disorders. Curr Psychiatry Rep. 2013;15.

17. Gadermann AM, Engel CC, Naifeh JA, Nock MK, Petukhova M, Santiago PN, et al. Prevalence of DSM-IV Major Depression Among U.S. Military Personnel: Meta-Analysis and Simulation. Mil Med. 2012;177:47–59.

18. Bailey DM, Brugniaux J V., Filipponi T, Marley CJ, Stacey B, Soria R, et al. Exaggerated systemic oxidative-inflammatory-nitrosative stress in chronic mountain sickness is associated with cognitive decline and depression. J Physiol. 2019;597:611–29.

19. Abbey SE, Garfinkel PE. Chronic fatigue syndrome and depression: Cause, effect, or covariate. Rev Infect Dis. 1991;13:S73–83.

20. Anderson G, Maes M, Berk M. Biological underpinnings of the commonalities in depression, somatization, and Chronic Fatigue Syndrome. Med Hypotheses. 2012;78:752–6. doi:10.1016/j.mehy.2012.02.023.

21. Corfield EC, Martin NG, Nyholt DR. Co-occurrence and symptomatology of fatigue and depression. Compr Psychiatry. 2016;71:1–10. doi:10.1016/j.comppsych.2016.08.004.

22. William WK. Zung Self-Rating Depression Scale. Encycl Qual Life Well-Being Res. 2014;7317–7317.

23. Gong Y, Han T, Chen W, Dib HH, Yang G, Zhuang R, et al. Prevalence of anxiety and depressive symptoms and related risk factors among physicians in China: A cross-sectional study. PLoS One. 2014;9:1–7.

24. Zhang C, Xue Y, Zhao H, Zheng X, Zhu R, Du Y, et al. Prevalence and related influencing factors of depressive symptoms among empty-nest elderly in Shanxi, China. J Affect Disord. 2019;245:750–6. doi:10.1016/j.jad.2018.11.045.

25. Yan R, Xia J, Yang R, Lv B, Wu P, Chen W, et al. Association between anxiety, depression, and comorbid chronic diseases among cancer survivors. Psychooncology. 2019;28:1269–77.

26. Lei L, Huang X, Zhang S, Yang J, Yang L, Xu M. Comparison of Prevalence and Associated Factors of Anxiety and Depression among People Affected by versus People Unaffected by Quarantine during the COVID-19 Epidemic in Southwestern China. Med Sci Monit. 2020;26:1–12.

27. Chalder T, Berelowitz G, Pawlikowska T, Watts T, Wessely L, Wright D, et al. Development of a fatigue scale. J Psychosom Res. 1993;37:147-153. doi:10.1016/0022-3999(93)90081-p

28. Jing MJ, Lin WQ, Wang Q, Wang JJ, Tang J, Jiang ES, et al. Reliability and construct validity of two versions of Chalder fatigue scale among the general population in mainland China. Int J Environ Res Public Health. 2016;13.
29. Yang JS, Xu HL, Chen PP, Sikandar A, Qian MZ, Lin HX, et al. Ataxic Severity Is Positively Correlated With Fatigue in Spinocerebellar Ataxia Type 3 Patients. Front Neurol. 2020;11 April:1–6.
30. Sajobi TT, Amoozegar F, Wang M, Wiebe N, Fiest KM, Patten SB, et al. Global assessment of migraine severity measure: Preliminary evidence of construct validity. BMC Neurol. 2019;19:1–9.
31. Gift AG, Narsavage G. Validity of the numeric rating scale as a measure of dyspnea. Am J Crit Care. 1998;7:200-204.
32. Johnson MJ, Close L, Gillon SC, Molassiotis A, Lee PH, Farquhar MC, et al. Use of the modified Borg scale and numerical rating scale to measure chronic breathlessness: A pooled data analysis. Eur Respir J. 2016;47:1861–4.
33. MacGregor KL, Funderburk JS, Pigeon W, Maisto SA. Evaluation of the PHQ-9 item 3 as a screen for sleep disturbance in primary care. J Gen Intern Med. 2012;27:339–44.
34. Wang J, Zhou Y, Liang Y, Liu Z. A large sample survey of tibetan people on the qinghai–tibet plateau: Current situation of depression and risk factors. Int J Environ Res Public Health. 2020;17:1–15.
35. Kious BM, Bakian A, Zhao J, Mickey B, Guille C, Renshaw P, et al. Altitude and risk of depression and anxiety: findings from the intern health study. Int Rev Psychiatry. 2019;31:637–45. doi:10.1080/09540261.2019.1586324.
36. Saligaut C, Chretien P, Daoust M, Moore N, Boismare F. Dynamic characteristics of dopamine, norepinephrine and serotonin metabolism in axonal endings of the rat hypothalamus and striatum during hypoxia: a study using HPLC with electrochemical detection. Methods Find Exp Clin Pharmacol. 1986;8:343-349.
37. Arregui A, Hollingsworth Z, Penney JB, Young AB. Autoradiographic evidence for increased dopamine uptake sites in striatum of hypoxic mice. Neurosci Lett. 1994;167:195–7.
38. Dunlop BW, Nemeroff CB. The role of dopamine in the pathophysiology of depression. Arch Gen Psychiatry. 2007;64:327–37.
39. Kraus C, Castrén E, Kasper S, Lanzenberger R. Serotonin and neuroplasticity – Links between molecular, functional and structural pathophysiology in depression. Neurosci Biobehav Rev. 2017;77:317–26. doi:10.1016/j.neubiorev.2017.03.007.
40. Lucca G, Comim CM, Valvassori SS, Réus GZ, Vuolo F, Petronilho F, et al. Increased oxidative stress in submitochondrial particles into the brain of rats submitted to the chronic mild stress paradigm. J Psychiatr Res. 2009;43:864–9. doi:10.1016/j.jpsychires.2008.11.002.
41. Jaillard AS, Mazetti P, Kala E. Prevalence of migraine and headache in a high-altitude town of Peru: A population-based study. Headache. 1997;37:95–101.
42. Yang Y, Ligthart L, Terwindt GM, Boomsma DI, Rodriguez-Acevedo AJ, Nyholt DR. Genetic epidemiology of migraine and depression. Cephalalgia. 2016;36:679–91.
43. Marmura MJ, Hernandez PB. High-Altitude Headache. Curr Pain Headache Rep. 2015;19.
44. Zhang Q, Shao A, Jiang Z, Tsai H, Liu W. The exploration of mechanisms of comorbidity between migraine and depression. J Cell Mol Med. 2019;23:4505–13.
45. Wu W, Yao H, Zhao HW, Wang J, Haddad GG. Down-regulation of Inwardly Rectifying K+ Currents in Astrocytes Derived from Patients with Monge’s Disease. Neuroscience. 2018;374:70–9. doi:10.1016/j.neuroscience.2018.01.016.

46. Stavrou NAM, Debevec T, Eiken O, Mekjavic IB. Hypoxia worsens affective responses and feeling of fatigue during prolonged bed rest. Front Psychol. 2018;9 MAR:1–10.

47. Fan JL, Kayser B. Fatigue and Exhaustion in Hypoxia: The Role of Cerebral Oxygenation. High Alt Med Biol. 2016;17:72–84.

48. Christley Y, Duffy T, Everall IP, Martin CR. The neuropsychiatric and neuropsychological features of chronic fatigue syndrome: Revisiting the enigma. Curr Psychiatry Rep. 2013;15.

49. Maes M. An intriguing and hitherto unexplained co-occurrence: Depression and chronic fatigue syndrome are manifestations of shared inflammatory, oxidative and nitrosative (IO&NS) pathways. Prog Neuro-Psychopharmacology Biol Psychiatry. 2011;35:784–94. doi:10.1016/j.pnpbp.2010.06.023.

50. Ainslie PN, Lucas SJE, Burgess KR. Breathing and sleep at high altitude. Respir Physiol Neurobiol. 2013;188:233–56. doi:10.1016/j.resp.2013.05.020.

51. Bloch KE, Buenzli JC, Latshang TD, Ulrich S. Sleep at high altitude: Guesses and facts. J Appl Physiol. 2015;119:1466–80.

52. Steiger A, Pawlowski M. Depression and sleep. Int J Mol Sci. 2019;20:1–14.

53. Simonson TS, Yang Y, Huff CD, Yun H, Qin G, Witherspoon DJ, et al. Genetic evidence for high-altitude adaptation in Tibet. Science (80- ). 2010;329:72–5.

54. Storz JF. Genes for high altitudes. Science (80- ). 2010;329:40–1.

55. Petousi N, Croft QPP, Cavalleri GL, Cheng HY, Formenti F, Ishida K, et al. Tibetans living at sea level have a hyporesponsive hypoxia-inducible factor system and blunted physiological responses to hypoxia. J Appl Physiol. 2014;116:893–904.

56. Muza SR. Military applications of hypoxic training for high-altitude operations. Med Sci Sports Exerc. 2007;39:1625–31.

**Tables**

**Table 1** Depression and symptoms of CMS according to demographic and working characteristics between HA and LA group
| Variables                           | HA group            | LA group            | P value |
|------------------------------------|---------------------|---------------------|---------|
|                                    | (n = 194)           | (n = 190)           |         |
| Age (years)                        | 23.76±4.09          | 23.64±3.89          | 0.767   |
| < 25                               | 124 (63.9%)         | 128 (67.4%)         | 0.477   |
| 25~                                | 70 (36.1%)          | 62 (32.6%)          |         |
| Deployment duration (months)       | 61.71±49.54         | 64.56±45.38         | 0.556   |
| ≤12                                | 26 (13.4%)          | 8 (4.2%)            | 0.002   |
| >12                                | 30 (15.5%)          | 22 (11.6%)          |         |
| >24                                | 138 (71.1%)         | 160 (84.2%)         |         |
| Educational level                  |                     |                     | 0.219   |
| Secondary school                   | 46 (23.7%)          | 33 (17.4%)          |         |
| High school                        | 118 (60.8%)         | 121 (63.7%)         |         |
| Junior college                     | 23 (11.9%)          | 32 (16.8%)          |         |
| Undergraduate or above             | 7 (3.6%)            | 4 (2.1%)            |         |
| Marital status                     |                     |                     | 0.458   |
| Single                             | 147 (75.8%)         | 150 (78.9%)         |         |
| Married                            | 47 (24.2%)          | 40 (21.1%)          |         |
| Only child or not                  |                     |                     | 0.115   |
| Yes                                | 91 (46.9%)          | 73 (38.4%)          |         |
| No                                 | 103 (53.1%)         | 117 (61.6%)         |         |
| Military rank                      |                     |                     | 0.855   |
| Private                            | 33 (17.0%)          | 31 (16.3%)          |         |
| Non-commissioned officer           | 161 (83.0%)         | 159 (83.7%)         |         |
| Fatigue                            | 7.37±2.95           | 6.14±2.64           | <0.001  |
| Migraine                           | 2.19±0.84           | 1.36±0.54           | <0.001  |
| Breathlessness                     | 1.18±0.78           | 0.37±0.50           | <0.001  |
| Sleep disturbance                  | 1.23±0.72           | 0.98±0.79           | 0.001   |
| SDS standard score                 | 47.43±10.42         | 43.18±10.13         | <0.001  |
| Depression (depression severity index ≥ 0.5) | <0.001 |
|--------------------------------------------|--------|
| Yes | 88 (45.4%) | 50 (26.3%) |
| Not | 106 (54.6%) | 140 (36.5) |

Abbreviations: *SDS Self Rating Depression Scale*

Table 1  Depression and symptoms of CMS according to demographic and working characteristics between HA and LA group
| Variables                        | HA group (n = 194) | LA group (n = 190) | P value |
|---------------------------------|--------------------|--------------------|---------|
| Age (years)                     | 23.76±4.09         | 23.64±3.89         | 0.767   |
| < 25                            | 124 (63.9%)        | 128 (67.4%)        | 0.477   |
| 25~                             | 70 (36.1%)         | 62 (32.6%)         |         |
| Deployment duration (months)    | 61.71±49.54        | 64.56±45.38        | 0.556   |
| ≤12                             | 26 (13.4%)         | 8 (4.2%)           | 0.002   |
| >12                             | 30 (15.5%)         | 22 (11.6%)         |         |
| >24                             | 138 (71.1%)        | 160 (84.2%)        |         |
| Educational level               |                    |                    | 0.219   |
| Secondary school                | 46 (23.7%)         | 33 (17.4%)         |         |
| High school                     | 118 (60.8%)        | 121 (63.7%)        |         |
| Junior college                  | 23 (11.9%)         | 32 (16.8%)         |         |
| Undergraduate or above          | 7 (3.6%)           | 4 (2.1%)           |         |
| Marital status                  |                    |                    | 0.458   |
| Single                          | 147 (75.8%)        | 150 (78.9%)        |         |
| Married                         | 47 (24.2%)         | 40 (21.1%)         |         |
| Only child or not               |                    |                    | 0.115   |
| Yes                             | 91 (46.9%)         | 73 (38.4%)         |         |
| No                              | 103 (53.1%)        | 117 (61.6%)        |         |
| Military rank                   |                    |                    | 0.855   |
| Private                         | 33 (17.0%)         | 31 (16.3%)         |         |
| Non-commissioned officer        | 161 (83.0%)        | 159 (83.7%)        |         |
| Fatigue                         | 7.37±2.95          | 6.14±2.64          | <0.001  |
| Migraine                        | 2.19±0.84          | 1.36±0.54          | <0.001  |
| Breathlessness                  | 1.18±0.78          | 0.37±0.50          | <0.001  |
| Sleep disturbance               | 1.23±0.72          | 0.98±0.79          | 0.001   |
| SDS standard score              | 47.43±10.42        | 43.18±10.13        | <0.001  |
| Depression (depression severity index $\geq 0.5$) | 88 (45.4%) | 50 (26.3%) |
|-----------------------------------------------|------------|------------|
| Not                                           | 106 (54.6%) | 140 (36.5%) |

Abbreviations: *SDS Self Rating Depression Scale*

Table 2 Factors associated with prevalence of depression among military plateau drivers (HA group)
| Variables | OR | 95% CI | P value |
|-----------|----|--------|---------|
|            |    | Lower  | Upper   |
| Age (years) |    |        |         |
| < 25       | Reference level | - | - | - |
| 25~        | 0.86 | 0.32 | 2.31 | 0.763 |
| Deployment duration (months) |    |        |         |
| ≤12        | Reference level | - | - | - |
| >12        | 0.62 | 0.07 | 5.42 | 0.667 |
| >24        | 0.73 | 0.23 | 2.28 | 0.585 |
| Educational level |    |        |         |
| Secondary school | Reference level | - | - | - |
| High school | 2.49 | 0.27 | 23.17 | 0.422 |
| Junior college | 2.70 | 0.32 | 22.64 | 0.361 |
| Undergraduate or above | 3.97 | 0.39 | 39.98 | 0.242 |
| Marital status |    |        |         |
| Single | Reference level | - | - | - |
| Married | 0.96 | 0.34 | 2.67 | 0.934 |
| Only child or not |    |        |         |
| Yes | Reference level | - | - | - |
| No | 0.67 | 0.34 | 1.32 | 0.242 |
| Military rank |    |        |         |
| Private | Reference level | - | - | - |
| Non-commissioned officer | 2.44 | 0.39 | 15.31 | 0.342 |
| Fatigue | 1.14 | 1.01 | 1.29 | 0.040 |
| Migraine | 1.83 | 1.13 | 2.95 | 0.014 |
| Breathlessness | 1.69 | 1.04 | 2.73 | 0.033 |
| Sleep disturbance | 1.78 | 1.03 | 3.07 | 0.039 |
| Variables                          | OR | 95% CI  | P value |
|-----------------------------------|----|---------|---------|
|                                   |    | Lower   | Upper   |
| **Age (years)**                   |    |         |         |
| < 25 Reference level              |    | -       | -       |
| 25~                               | 0.86| 0.32    | 2.31    | 0.763 |
| **Deployment duration (months)**  |    |         |         |
| ≤12 Reference level               |    | -       | -       |
| >12                               | 0.62| 0.07    | 5.42    | 0.667 |
| >24                               | 0.73| 0.23    | 2.28    | 0.585 |
| **Educational level**             |    |         |         |
| Secondary school Reference level  |    | -       | -       |
| High school                       | 2.49| 0.27    | 23.17   | 0.422 |
| Junior college                    | 2.70| 0.32    | 22.64   | 0.361 |
| Undergraduate or above            | 3.97| 0.39    | 39.98   | 0.242 |
| **Marital status**                |    |         |         |
| Single Reference level            |    | -       | -       |
| Married                           | 0.96| 0.34    | 2.67    | 0.934 |
| **Only child or not**             |    |         |         |
| Yes Reference level               |    | -       | -       |
| No                                | 0.67| 0.34    | 1.32    | 0.242 |
| **Military rank**                 |    |         |         |
| Private Reference level           |    | -       | -       |
| Non-commissioned officer          | 2.44| 0.39    | 15.31   | 0.342 |
| **Fatigue**                       | 1.14| 1.01    | 1.29    | 0.040 |
| **Migraine**                      | 1.83| 1.13    | 2.95    | 0.014 |
| **Breathlessness**                | 1.69| 1.04    | 2.73    | 0.033 |
Figures

Drivers in the Goimud motor transport base  
\( n = ? \) (classified) 

Drivers in the Fujian motor transport base  
\( n = ? \) (classified) 

Selected drivers as HA group  
\( n = 200 \) (100 \%) 

Selected drivers as LA group  
\( n = 200 \) (100 \%) 

Living at HA before enlisted  
\( n = 2 \) (1.0 \%) 

Living at HA before enlisted  
\( n = 4 \) (2.0 \%) 

Went to LA recently  
\( n = 3 \) (1.5 \%) 

Went to HA recently  
\( n = 1 \) (0.5 \%) 

remained in HA group  
\( n = 195 \) (97.5 \%) 

remained in LA group  
\( n = 195 \) (97.5 \%) 

Incomplete response  
\( n = 1 \) (0.5 \%) 

Incomplete response  
\( n = 5 \) (2.5 \%) 

Participants in HA group  
\( n = 194 \) (97.0 \%) 

Participants in LA group  
\( n = 190 \) (95.0 \%) 

Total Participants  
\( n = 384 \)

Figure 1

Study flowchart