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Development of the Plateau Multidimensional Health Questionnaire

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Abstract: *Migrants to high-altitude regions face multi-system health risks but lack comprehensive assessment tools. This study developed the "Plateau Multidimensional Health Questionnaire" and surveyed 1237 migrants in plateau region (male 74.8%, female 25.2%; age 22.35 ± 6.51 years). Exploratory factor analysis identified five factors: Digestive-Autonomic Nervous Dysfunction (F1, variance 12.53%), Abnormal Thermoregulation (F2), Skin Metabolism Abnormalities (F3), Immune-Inflammatory Response (F4) , and Endocrine Imbalance (F5) ,which collectively explained 53.47% of the variance (Cronbach's α = 0.708). The results showed: F1 was significantly positively correlated with F2-F5 (r = 0.287–0.379, p < 0.01), suggesting a pivotal role of autonomic regulation in multi-system comorbidity. Female participants scored significantly higher than males on F1-F3 (p < 0.01), which may be related to estrogen-immune interactions. The group aged ≥31 years had higher incidence of F1/F4, while the 20-25 years group had a prominent F3, reflecting age-specific exposure risks. This study provides the first multidimensional assessment framework for plateau health management, with future research needed to validate these findings using longitudinal data.*

Keywords: *Plateau Health, Migrants, Questionnaire Development*

1. Introduction

The plateau environment, characterized by low atmospheric pressure, low oxygen, intense ultraviolet radiation, and extreme diurnal temperature variation, poses multidimensional challenges to the physiological homeostasis of long-term migrants. Previous studies have shown that chronic hypoxia exposure can lead to multi-system dysfunction through mechanisms such as the activation of the sympathetic nervous system[1], induction of oxidative stress [2], and disruption of immune regulation[3]. However, existing health assessment tools mainly focus on single system symptoms, such as the Acute Mountain Sickness (AMS) scale [4], and lack a comprehensive evaluation of multi-system comorbidities, including digestion, nervous, and endocrine systems. Furthermore, the health heterogeneity within the plateau migrant population, such as gender and age differences, and their potential interaction mechanisms, remain unclear [5].

Recent studies suggest that hypoxia at high altitudes may induce multi-systemic dysregulation through mechanisms such as the "gut-brain axis"[6] and the "immune-endocrine network"[7]. For example, disrupted gut microbiota aggravates spatial memory dysfunction induced by high altitude exposure[6], while ultraviolet-induced skin metabolic abnormalities may have a bidirectional association with chronic inflammation [8]. However, these hypotheses still lack empirical data based on human populations, and gender-specific health risks have not been systematically evaluated.

This study, based on the biopsychosocial medical model, developed a multidimensional health symptom assessment questionnaire for plateau migrants. Through a cross-sectional survey of 1237 long-term migrants in plateau region,The study also aims to explore the comorbidity patterns between health dimensions and validate the systemic compensation hypothesis during the plateau adaptation process, and to analyze the demographic differences (gender, age) in health issues, so as to provide a basis for precise interventions for high - risk populations.The results of this study will fill the gap in multidimensional health assessment tools in plateau medicine and provide a theoretical framework for future mechanistic research.

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2. Questionnaire Development

2.1. Research Purpose

This study aims to explore people's understanding and perceptions of plateau health through qualitative research methods. By reviewing literature, conducting interviews, and developing questionnaires, we aim to gather firsthand information on the views and understandings of plateau health and establish an item bank for plateau health.

2.2. Research Methods

A review of literature related to plateau health was conducted. We initially performed extensive searches in Chinese databases (such as CNKI and Wan fang) as well as English databases (such as PubMed, Google Scholar, and Springer) using keywords related to "plateau health." Through this search, we obtained a large body of literature on plateau health. By systematically analyzing these sources, we were able to comprehensively understand the current state of plateau health assessments, providing theoretical and practical support for the subsequent design and development of the questionnaire. The next steps involved expert interviews and open-ended questionnaires to generate initial items, which were then finalized after evaluation by experts in the field.

2.3. Questionnaire Development Results

2.3.1. Exploratory Factor Analysis

(1) Participants

Participants from various regions of plateau region Autonomous Region (including Lhasa, Shannan, Nyingchi, Shigatse, etc.) and different sectors (such as students, tourists, government employees, etc.) were invited to complete the questionnaire. A total of 838 completed questionnaires were collected. All participants provided informed consent. Among the participants, 74.8% were male and 25.2% were female. The average age was 22.35 years (SD = 6.51).

(2) Results

Exploratory factor analysis was conducted on 19 items, yielding a Kaiser-Meyer-Olkin (KMO) value of 0.813, and Bartlett's test of sphericity was significant ($p < 0.001$), indicating that factor analysis was appropriate. Principal component analysis with orthogonal rotation was performed. Six factors with eigenvalues greater than 1 were extracted, explaining 52.073% of the total variance. Based on the scree plot and the theoretical framework of the questionnaire, five factors were retained for principal component analysis. Following the principle that factor loadings should have an absolute value greater than 0.4, and the absolute difference in loadings between factors should exceed 0.20, items 5, 6, 9, 15, and 17 were removed, leaving 15 items. A further factor analysis was performed on the remaining items, with all items showing loadings greater than 0.4 on the corresponding factors. The five factors explained 53.472% of the total variance. The factors are described as follows, with factor loadings listed in Table 1:

F1: Digestive-Autonomic Nervous Dysfunction – This factor contains 5 items that reflect the association between digestive system issues and autonomic nervous dysfunction, such as gastrointestinal motility disorders and neurogenic tinnitus.

F2: Abnormal Thermoregulation – This factor contains 3 items, indicating abnormalities in central or peripheral thermoregulation mechanisms, possibly related to hypothalamic-autonomic dysregulation.

F3: Skin and Pigmentation Abnormalities – This factor includes 3 items that reflect skin metabolic abnormalities or pigmentation issues, potentially linked to inflammation or endocrine disorders.

F4: Immune-Inflammatory Response – This factor contains 3 items, suggesting chronic immune activation or mucosal inflammation, such as allergic rhinitis or recurrent respiratory infections.

F5: Endocrine Imbalance, includes 1 item, which indicates sexual health issues leading to endocrine imbalance.

2.3.2. Item Analysis

Based on Table 1 and Table 2, it can be seen that the factor loadings for each item range from 0.415

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to 0.821, the correlations between each item and its corresponding factor range from 0.464 to 0.821, the mean scores for the items range from 1.05 to 1.32, and the standard deviations range from 0.23 to 0.79. The internal consistency reliability (Cronbach's α) is 0.708. These indicators suggest that the items of the questionnaire meet the measurement requirements.

Table 1: Factor Loading's Table.

Item		F1 Digestive-Autonomic Dysfunction	F2 Abnormal Thermoregulation	F3 Skin Metabolism & Pigmentation Abnormalities	F4 Immune-Inflammatory Response	F5: Sexual Function-Endocrine Imbalance
Q10	Indigestion	0.688				
Q8	Constipation	0.681				
Q7	Tinnitus	0.474				
Q18	Difficulty Sweating	0.444				
Q16	Slow Heartbeat	0.415				
Q2	Chronic Low Fever		0.82			
Q3	Chronic High Fever		0.74			
Q1	Insensitive to Temperature		0.594			
Q13	Yellow Skin			0.755		
Q14	Red Skin			0.67		
Q12	Dark Skin			0.643		
Q19	Prone to Illness				0.767	
Q11	Runny Nose				0.711	
Q4	Joint Pain or Ache				0.626	
Q20	Endocrine Imbalance					0.821
Eigenvalue		3.235	1.45	1.224	1.073	1.032
Variance Explained (%)		12.53	11.149	11.024	10.615	8.108
Cumulative Variance Explained (%)		12.53	23.679	34.703	45.319	53.427

Table 2: Item Analysis of the Scale.

Factor	Item No.	Mean	Standard Deviation	Correlation with Corresponding Factor
F1	Q18	1.11	0.42	0.524**
F1	Q19	1.16	0.5	0.642**
F1	Q24	1.11	0.41	0.588**
F1	Q46	1.05	0.23	0.464**
F1	Q52	1.32	0.79	0.708**
F2	Q1	1.21	0.54	0.841**
F2	Q2	1.07	0.32	0.733**
F2	Q3	1.05	0.26	0.594**
F3	Q37	1.14	0.5	0.784**
F3	Q38	1.1	0.42	0.779**
F3	Q39	1.09	0.36	0.631**
F4	Q8	1.19	0.55	0.714**
F4	Q35	1.29	0.7	0.821**
F4	Q54	1.11	0.34	0.621**
F5	Q55	1.07	0.36	1.000**
** means $p < 0.01$ (two-tailed)				

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3. Correlations Between Health Factors

Table 3: Factor Correlations.

Variable	F1	F2:	F3	F4	F5
F1: Digestive-Autonomic Dysfunction	1				
F2: Temperature Regulation Abnormalities	0.287**	1			
F3: Skin Metabolism and Pigmentation Abnormalities	0.379**	0.201**	1		
F4: Immune-Inflammatory Response	0.304**	0.150**	0.283**	1	
F5: Sexual Function-Endocrine Disorders	0.211**	0.168**	0.135**	0.164**	1
** means $p < 0.01$ (two-tailed)					

According to Table 3, it can be seen that all dimensions are significantly positively correlated with each other ($p < 0.01$). The differences in the correlation strength between dimensions suggest that the digestive system and autonomic nervous function may play a central role in the overall health network, while the endocrine system's interaction with other systems is relatively independent. That confirms the associations between health dimensions are statistically significant.

4. Health Issue Distribution and Demographic Differences

4.1. Demographic Information

The combined sample of 1237 participants, including those used for exploratory factor analysis and the subsequent descriptive statistics, is analyzed for the distribution of health issues. Detailed demographic information is provided in Table 4.

Table 4: Demographic Information.

Category	N	Mean	Standard Deviation
Gender		1.29	0.46
Male	874		
Female	365		
Age		22.48	5.92
17-19 years	434		
20-22 years	461		
23-25 years	165		
26-30 years	62		
31+ years	117		
Height	1237	170.49	8.17
Weight	1231	64.62	13.03
BMI	1237	22.04	4.37

4.2. Gender Differences

All tests were conducted using the Welch correction (due to non-integer degrees of freedom, indicating unequal variances), and the robustness of the results was ensured by adjusting for the degrees of freedom. The results showed that the digestion, temperature regulation, and skin dimensions had significantly higher scores for females compared to males ($p < 0.01$), with the effect direction being consistent (confidence intervals not including zero).

Table 5: Gender Differences in Health Factors.

Variable	Male (n=874)	Female (n=365)	F	t	df	p
F1 Digestion Dimension	5.48 ± 1.35	6.12 ± 1.88	73.025	-5.88	528.27	0
F2 Temperature Regulation	3.16 ± 0.56	3.38 ± 0.98	73.181	-3.94	465.27	0
F3 Skin	3.21 ± 0.87	3.48 ± 1.55	48.426	-3.11	462.46	0
F4 Immunity	3.35 ± 1.01	3.48 ± 1.15	9.293	-1.86	608.41	0.06
F5 Endocrine	1.05 ± 0.25	1.09 ± 0.43	20.604	-1.87	475.50	0.06

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Although the gender differences in the immunity and endocrine dimensions were close to the critical value (p = 0.06), the effect size was small and the confidence intervals included zero, indicating that these differences were not of practical significance.

4.3. Age Differences

Table 6: Age-based One-Way ANOVA.

Dimension	Age Group	N	SD	M	F (Welch's ANOVA)	P (Welch's ANOVA)	Post-hoc Comparisons
F1 Digestive Dimension	1	434	5.77	1.58	15.528	<0.001	1>2,3 5>1,2,3,4
	2	461	5.34	0.93			
	3	165	5.34	0.86			
	4	62	5.73	1.28			
	5	117	7.01	2.94			
F2 Temperature Dimension	1	434	3.30	0.87	3.873	0.004	1>2 5>3
	2	461	3.16	0.56			
	3	165	3.13	0.65			
	4	62	3.19	0.47			
	5	117	3.38	0.80			
F3 Skin Dimension	1	434	3.32	1.16	4.885	0.001	1>3 5>2,3
	2	461	3.18	0.75			
	3	165	3.12	0.48			
	4	62	3.50	1.58			
	5	117	3.75	2.08			
F4 Immune Dimension	1	434	3.35	0.95	2.75	0.029	5>1,2
	2	461	3.31	1.06			
	3	165	3.37	0.79			
	4	62	3.47	1.02			
	5	117	3.79	1.54			
F5 Endocrine Dimension	1	434	1.02	0.22	8.195	<0.001	5>1,2,3
	2	461	1.02	0.15			
	3	165	1.01	0.11			
	4	62	1.16	0.58			
	5	117	1.36	0.69			

The age groups are as follows: 17-19 years as Group 1, 20-22 years as Group 2, 23-25 years as Group 3, 26-30 years as Group 4, and 31 years and older as Group 5. According to the results in Table 6, different trends in various health dimensions were observed with age. Specifically, younger individuals exhibit poorer digestive function, while older individuals also show suboptimal digestive health. Younger individuals have poorer temperature regulation, and older individuals experience similar issues with temperature regulation. Both younger and older age groups display poorer skin health. Immunity tends to decline in older individuals. Additionally, issues related to sexual health increase with age.

5. Discussion

5.1. Multi-system Comorbidity Model and Plateau Adaptation Mechanisms

This study, for the first time, revealed the comorbid associations of digestive-autonomic dysfunction (F1), temperature regulation abnormalities (F2), skin metabolic abnormalities (F3), immune-inflammatory responses (F4), and endocrine dysfunction (F5) in highland migrants through the multi-dimensional health questionnaire. F1, which explains the highest variance (12.53%), showed significant positive correlations with F1-F5 (r = 0.135 - 0.379), aligning with the "central autonomic regulatory imbalance hypothesis"[9]. Hypoxia may activate the hypothalamic-pituitary-adrenal (HPA) axis while inducing gut microbiota dysbiosis [10] and mucosal barrier damage, which leads to multi-directional interactions between the autonomic, digestive, and immune systems[11]. This finding supports the existence of a systemic threshold in plateau adaptation compensatory mechanisms—when a single system (such as the autonomic nervous system) fails to compensate, it may trigger a multi-system coordinated dysfunction[12].

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5.2. Physiological and Socio-Cultural Explanations for Gender Differences

The significant higher scores in the digestive, temperature regulation, and skin dimensions among women ($p<0.01$) may be attributed to several factors.

Estrogen's Impact: Estrogen has a dual role in regulating physiological processes. It affects blood vessel dilation and constriction by modulating nitric oxide synthase activity [13], which may contribute to increased susceptibility to temperature regulation abnormalities (F2) in women. Furthermore, the widespread distribution of estrogen receptors in the smooth muscle of the gastrointestinal tract [14] could exacerbate gastrointestinal motility issues, which are often triggered by hypoxia (F1).

Immune System Differences: Women tend to exhibit a Th1/Th2 immune balance that favors Th2 dominance [15], potentially heightening the skin's inflammatory response to ultraviolet (UV) radiation (F3). This is consistent with the observed higher prevalence of skin metabolic abnormalities in women in our study.

5.3. Pathophysiological Significance of Age Stratification

In high-altitude environments, age-related physiological differences affect digestive, thermoregulatory, and skin conditions. Young adults (18-22) experience gastrointestinal issues due to reduced blood flow and enzyme secretion under hypoxia, with delayed gastric emptying and increased bloating [16]. Irregular eating habits and sympathetic nervous system hyperactivity worsen these symptoms. In contrast, individuals over 30 show greater physiological decline, including impaired gut barrier function and increased intestinal permeability [17], as well as microbial imbalances[18].

Metabolic decline after age 30 reduces brown adipose tissue activity, impairing thermoregulation and slowing core body temperature recovery during cold exposure [19]. Skin collagen production decreases, and high-altitude UV radiation accelerates collagen breakdown [20]. Immune function also declines with age, with hypoxia exacerbating inflammation and oxidative stress [21]. Overall, hypoxia and aging combine to create distinct adaptive challenges for different age groups.

5.4. Limitations of the Study

The study's sample selection may have introduced bias, as it included a disproportionately high percentage of males (74.8%) and lacked sufficient representation of older participants. This imbalance may have resulted in an underestimation of health issues specific to females, such as menstrual irregularities, and age-related comorbidities. Furthermore, the study's inability to measure key biological indicators, such as HPA axis activity (e.g., plasma cortisol) or oxidative stress markers (e.g., MDA), limits the ability to draw mechanistic inferences. Without these measures, it is challenging to determine the critical threshold between physiological adaptation and pathological damage.

5.5. Practical Implications and Future Directions

For female migrants, health management strategies should prioritize the monitoring of autonomic nervous function, such as heart rate variability, and the integrity of the skin barrier. For the elderly population, regular screenings for digestive and immune function are essential. To optimize research design, a longitudinal cohort study tracking the health trajectory of migrants, coupled with multi-omics technologies (e.g., gut microbiome and inflammatory cytokine profiles), could provide valuable insights into the mechanisms of comorbidities. Additionally, the existing questionnaire could be enhanced by integrating the Lake Louise Acute Mountain Sickness Score[4], creating a comprehensive “acute-chronic” health risk assessment system for high-altitude migrants.

6. Conclusions

This study provides the first multidimensional assessment framework for high-altitude health management, filling the gap in multidimensional health assessment tools in high-altitude medicine and laying a theoretical foundation for future mechanistic research.

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References

[1] FRISANCHO A R. Developmental functional adaptation to high altitude [J]. American Journal of Human Biology, 2013, 25(2): 151-68.
[2] PENA E, BRITO J, EL ALAM S, et al. Oxidative stress, kinase activity and inflammatory implications in right ventricular hypertrophy and heart failure under hypobaric hypoxia [J]. International journal of molecular sciences, 2020, 21(17): 6421.
[3] FACCO M, ZILLI C, SIVIERO M, et al. Modulation of immune response by the acute and chronic exposure to high altitude [J]. Medicine and science in sports and exercise, 2005, 37(5): 768-74.
[4] RC R, PH H, AM L, et al. The 2018 Lake Louise acute mountain sickness score [J]. high altitude medicine & biology, 2018, 19(1): 4-6.
[5] WEST J B, SCHOENE R B, MILLEDGE J S, et al. High altitude medicine and physiology [M]. Hodder Arnold London, 2007.
[6] ZHANG X, JIA X, WANG S, et al. Disrupted gut microbiota aggravates spatial memory dysfunction induced by high altitude exposure: A link between plateau environment and microbiome–gut–brain axis [J]. Ecotoxicology and Environmental Safety, 2023, 259: 115035.
[7] LI Z, WANG S, GONG C, et al. Effects of environmental and pathological hypoxia on male fertility [J]. Frontiers in Cell and Developmental Biology, 2021, 9: 725933.
[8] JIMENEZ-SANCHEZ M, CELIBERTO L S, YANG H, et al. The gut-skin axis: a bi-directional, microbiota-driven relationship with therapeutic potential [J]. Gut Microbes, 2025, 17(1): 2473524.
[9] JULIAN C G, MOORE L G. Human genetic adaptation to high altitude: evidence from the Andes [J]. Genes, 2019, 10(2): 150.
[10] ZHANG Y, LUO H, NIU Y, et al. Chronic intermittent hypoxia induces gut microbial dysbiosis and infers metabolic dysfunction in mice [J]. Sleep Medicine, 2022, 91: 84-92.
[11] LUO Z, TIAN M, YANG G, et al. Hypoxia signaling in human health and diseases: implications and prospects for therapeutics [J]. Signal transduction and targeted therapy, 2022, 7(1): 218.
[12] LEONE T C, LEHMAN J J, FINCK B N, et al. PGC-1α deficiency causes multi-system energy metabolic derangements: muscle dysfunction, abnormal weight control and hepatic steatosis [J]. PLoS biology, 2005, 3(4): e101.
[13] GUO X, RAZANDI M, PEDRAM A, et al. Estrogen induces vascular wall dilation: mediation through kinase signaling to nitric oxide and estrogen receptors α and β [J]. Journal of Biological Chemistry, 2005, 280(20): 19704-10.
[14] CHEN C, GONG X, YANG X, et al. The roles of estrogen and estrogen receptors in gastrointestinal disease [J]. Oncology letters, 2019, 18(6): 5673-80.
[15] CHIANG S S W. Th1/Th2 imbalance in schizophrenia [D]; lmu, 2005.
[16] MAITY C, PARUA S, MONDAL K C. IMPACT OF HYPOBARIC HYPOXIA ON THE PATHOPHYSIOLOGY OF GI SYSTEM: EVALUATION OF THE ROLES OF INDIGENOUS MICROBIOTA [J]. INDIAN JOURNAL OF PHYSIOLOGY AND ALLIED SCIENCES, 2016, 70(02): 68-75.
[17] CHENG J, SUN Y, ZHAO Y, et al. Research progress on the mechanism of intestinal barrier damage and drug therapy in a high altitude environment [J]. Current drug delivery, 2024, 21(6): 807-16.
[18] ZHANG J, ZHANG J, WANG R, et al. Effects of gut microbiota on drug metabolism and guidance for rational drug use under hypoxic conditions at high altitudes [J]. Current Drug Metabolism, 2019, 20(2): 155-65.
[19] ROGERS N H. Brown adipose tissue during puberty and with aging [J]. Annals of medicine, 2015, 47(2): 142-9.
[20] WATSON R E, GIBBS N K, GRIFFITHS C E, et al. Damage to skin extracellular matrix induced by UV exposure [J]. Antioxidants & redox signaling, 2014, 21(7): 1063-77.
[21] OBEAGU E, MUHIMBURA E, OBEAGU G. Hypoxia-Induced Oxidative Stress: Maternal and Fetal Implications [J]. Elite Journal of Haematology, 2024, 2(8): 57-72.