Suboptimal Health Status of High School Students in Guangzhou, Shanxi, and Tibet, China: A Cross-Sectional Study

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Abstract: Suboptimal health status (SHS) is a state between health and disease, has several associated factors, although, its underlying mechanism is still unclear. This study aimed to investigate the status of SHS and its associated factors of high school students in three areas of China (Shanxi, Guangzhou, and Tibet). A multidimensional sub-health questionnaire of adolescent (MSQA) is used to evaluate SHS. Among 1461 respondents, females proportion 56.47% was higher than males 43.53% where SHS was higher in Shanxi, followed by Tibet and then Guangzhou. The rural area, grade, lack of sleep, home visit in a week, lack of exercise, a heavy burden of study, smoking, drinking, and fewer friends were the risk factors of SHS, while, families living status, seeking help, and extroversion were the protective factors. SHS is significantly associated with different influencing factors. For comprehensive prevention and control measures, reduce the risk factors, and enhance the protective factors.

Keywords: suboptimal health status; associated factors; high school students; Shanxi; Guangzhou; Tibet; China

1. Introduction

Health is the functional phenomenon of human-being. The condition of being sound in body, mind, spirit, and free from disease or pain is the meaning of health [1]. In 1946s, The World Health Organization (WHO) defined that “health is a state of complete physical, mental, and social well-being and, not merely the absence of
disease or infirmity”[2]. Likewise, the suboptimal health or sub-health status, also known as suboptimal health status (SHS)[3] is the physical state of people which is generally undiagnosed [4], however, some changes in psychological behavior or physical characteristics can observe [5]. In fact, SHS is an intermediate state between health and disease condition [6]. In this state, there are no organic lesions in the body, only characterized by persistent and recurrent fatigue, headaches, dizziness, anxiety, depression, as well as a series of symptoms including non-specific pain and sleep disorders [6–8].

Several studies suggested that SHS is as an intermediate state between health and disease, which is due to the physical, psychological, and social stress of an individual [4,9–12]. Due to the physical and psychological behavior, the overall coordination of the body system become imbalance and dysfunction e.g. the nervous system, endocrine system, and immune system that lead to the decline of physiological, psychological, and social functions; however, the body has not yet reached the disease stage [6,8]. Therefore, it is also regarded as a subclinical, reversible stage of chronic diseases [3,6]. Because, it has been known that SHS is a potential risk factor for chronic diseases such as type-II diabetes mellitus, cardiovascular and stroke etc [6,11,13]. A number of studies have revealed that SHS is mainly influenced by lifestyle factors [4,9,14]; these factors have a close relationship with psychological symptoms or behavior of individuals [12,15]. Over time, with the rapid development of technology and changes in environment and lifestyles in China, the risk of SHS has been increasing consistently[11]. Thus, SHS has been recognized as a public health challenge globally, including China [10,11,13,16].

In addition, some scholars believe that the changes in the living environment, over work-load, interpersonal relationship, lack of sleep time, excessive psychological stress, unbalanced diet, and an inappropriate exercise may lead to the formation of SHS. Likewise, a study reported that socio-cultural factors are the key determinants of SHS of students [9]. Furthermore, a survey conducted by Xie et al. among the middle school students’ found that school environmental and psychological factors, life events, lifestyle, social, natural, and family factors are the risk factors for SHS [17]. Similarly, Tu et al. [18], reported that the causes of SHS among teenagers/adolescence are excessive academic burden, family stress, noise, sleep time, less exercise, social and living environmental impacts, lifestyle, and physiological factors. Similarly, Fang et al. [19], found that drug abuse, eating habits, weight loss, exercise, internal injury, suicide, and internet addiction are the major risk factor for the psychological SHS in middle school students. To date, there has not been found the exact cause of the SHS. It has believed that SHS occurs due to different associated factors, although, its underlying mechanism is remaining unclear.

Previous studies have quantified that SHS is a public health problem in China. However, studies regarding SHS and its associated factors of high school students
in the study settings are limited. Therefore, this study aimed to examine the SHS of High School Students in Guangzhou, Shanxi, and Tibet, and we also quantify the associated factors of SHS among participants.

2. Materials and Methods

A community based, cross-sectional study conducted in China to investigate the SHS and its associated factors among high school students. We first selected three regions in China by means of convenient sampling (central areas in the central part: Shanxi Yuci, developed coastal areas: Guangzhou, Guangdong, remote areas in the west: Linzhi, Tibet) [20]. We selected key high school and ordinary high school. In each school, two classes from each grade student (High-I, II & III) were randomly selected by a stratified cluster sampling method. The sample size of this survey was calculated based on the National Normal Model Survey, where the detection rate of physical SHS and psychological SHS of high school students in China were (34.6%–53.9%) [21], the relative error was not more than 20%, and the confidence level reached 95%. The requirements are calculated by substituting the formula to obtain a minimum sample size of 182 in each region and 546 in three regions. In this survey, a total of 1472 high school students were surveyed. Excluded the questionnaires having missing items (leakage rate >10%), 1461 students were effectively surveyed with a 99.25% effective rate, which could meet the sample size requirements for this study.

2.1. SHS evaluation

Since our study was based on the Chinese population, we used the “Multidimensional sub-health Questionnaire of Adolescents (MSQA)” to know the SHS of respondents [21]. MSQA is an effective, sensitive, and validated SHS tool for adolescents [22]. The adolescent’s degree of SHS was evaluated by the level of physiological SHS and psychological SHS. MSQA questionnaire has 71 items; each item has 6 levels. The score of SHS is 1 to 6 points. The higher score of the point indicates the more serious SHS [21]. (Appendix-1)

2.2. Associated factors of SHS

The researcher from other countries has been using chronic fatigue as a syndrome in the research content [23], while its definition is different from the SHS. Therefore, this study combined the actual situation of Chinese students based on the Chinese scholars’ studies and the current knowledge of sub-health theories regarding factors affecting the SHS [21,24]. The factors affecting SHS are divided into self-factors (Gender, ethnicity, BMI index, grade, whether they are only children, time spent on school, sleep time, learning burden, frequency on exercise, internet surfing, smoking habit, alcohol consumption, diet, seeking help, personality, etc), family factors (family location, family structure, parental expectations, parental education, the annual income of family, level), school factors (key high school and ordinary high school), and other factors (student source, interpersonal relationship) etc (S.Table 1).

2.3. Data collection
The pre-test is conducted prior to the formal investigation. The first grade of an ordinary high school in Guangzhou was selected by means of convenient sampling for the pre-test. The information associated with survey questions and calculated scales were revised after getting feedback from the pre-test and then finalized the questionnaire for the final study.

Students are filled with information anonymously by means of centralized filling, independent answering, on-the-spot recycling, and on-the-spot investigation. At the spot, the local education authorities and their subordinate schools co-operated closely. Investigators collect all filled questionnaires after the survey is completed. The interview/survey was excluded from those participants who declined to participate in the survey. The questionnaire was finished by each respondent within 20 min. All information of the respondents was kept strictly confidential.

2.4. Ethical Approval

Ethical approval had been approved by the Ethics Committee of the School of Public Health, Sun Yat-Sen University, Guangzhou, China. The ethical approval number is 2018 (050). The written and verbal sign was taken with each respondent in an informed consent form at the beginning of each survey.

2.5. Statistical analysis

Epidata-3.1 software is used to record the database. Normality distributed quantitative data were displayed as mean and standard deviations, where non-normally distributed data were represented as medians and quartiles (P_{25}-P_{75}). Qualitative data were presented as a rate or percentage. A Pearson chi-square ($\chi^2$) test was applied to compare between groups. The influencing factor of SHS was estimated using logistic regression analysis for multivariate analysis, by adjusted Odds ratios (AOR) and 95% confidence interval (CI). All statistical analyses carried out using SPSS 23.0 software. All reported P values were two-sided, and P<0.05 was considered statistically significant.

3. Results

3.1. Basic characteristics of respondents

A total of 1472 respondent, 11 participants were excluded due to missing items or information in the questionnaire. Finally, 1461 high school students were enrolled in this survey. There were 43.53% (636) male and 56.47% (825) female with the mean age of 17.30 ± 1.27 years, and participants from Shanxi 31.76% (464), Guangzhou 33.61% (491), and Tibet 34.63% (506) (STable. 2). The result showed that tiredness and fatigue were high (11.98%) observe in physical SHS, while challenging to study at home (19.10%) in psychological SHS, among other symptoms, detail about the symptoms of both groups is displayed in Table1.

Table 1. Symptoms of SHS and Mental SHS
| Sub-health symptoms                      | Respondent | Detection rate (%) | Mental sub-health symptoms                      | Respondent No. | Detection rate (%) |
|-----------------------------------------|------------|--------------------|------------------------------------------------|---------------|--------------------|
| Tiredness, Fatigue                      | 175        | 11.98              | It’s hard to study at home                     | 279           | 19.10              |
| Dry eyes                                | 149        | 10.20              | Concentration on study                        | 233           | 15.95              |
| Nasal congestion                        | 128        | 8.76               | Unwilling to talk to others                   | 215           | 14.72              |
| I can’t sleep well.                     | 121        | 8.28               | I don’t want to see help                       | 209           | 14.31              |
| Drink more and eat more                 | 120        | 8.21               | Hesitate                                       | 207           | 14.17              |
| Wake up too early                       | 115        | 7.87               | Difficult to remember learning content        | 205           | 14.03              |
| Difficulty falling asleep               | 112        | 7.67               | Unnecessary thoughts                          | 203           | 13.89              |
| Sore eyes                               | 102        | 6.98               | Irritable                                      | 200           | 13.69              |
| Weak limbs                              | 99         | 6.78               | No hope in the future                         | 170           | 11.64              |
|                                         |            |                    | Do not trust others                           | 165           | 11.29              |
|                                         |            |                    | Worried about the teacher asking questions    | 164           | 11.23              |
|                                         |            |                    | Feel difficulty of learning                   | 163           | 11.61              |

The survey results showed that there were significant differences in the physical SHS and psychological SHS along with different detection rates among the high school students in the three regions. Psychological SHS was higher in Shanxi (20.69%) followed by Tibet (18.77%) and Guangzhou (13.03%) among surveyed populations (S.Table 3).

3.2. SHS detection Score and rate by gender

The results of this study showed that the detection rate of physical SHS symptoms and the Psychological SHS of females was higher than that of males, which is the statistically significant (STable 3,4,5).

3.3. Multiple logistic regression analysis of influencing factors with SHS and Psychological SHS

In order to know the comprehensive effect of the factors affecting the SHS, a stepwise multi-factor unconditional logistic regression analysis was carried out. The result of this analysis showed that the region, lack of sleep time, heavy learning burden, lack of exercise, drinking alcohol, lack of frequent home visit, and eating habit were the
statistically significant associated risk factors of SHS, while an hour of daily internet access was found to be a protective factor for the SHS (Table 2).

### Table 2. Detection of SHS in different regions

| Area   | Number of respondents | Sub-health Symptom check-out | Psychological SHS Symptom check-out |
|--------|-----------------------|------------------------------|------------------------------------|
|        |                       | Status check out             | Status check out                   |
| Shanxi | 464                   | 207(44.61)                   | 242(52.16)                         |
|        |                       | 115(24.78)                   | 96(20.69)                          |
| Guangdong | 491               | 188(38.29)                   | 203(41.34)                         |
|        |                       | 88(17.93)                    | 64(13.03)                          |
| Tibet  | 506                   | 199(39.33)                   | 229(45.26)                         |
|        |                       | 106(20.95)                   | 95(18.77)                          |
| Chi test | $\chi^2$            | 4.520                        | 11.459                             |
|        |                       | 6.754                        | 10.640                             |
|        |                       | 0.104                        | 0.003                              |
|        |                       | 0.034                        | 0.005                              |
|        |                       | Shanxi,                      | Shanxi$^b$,                         |
|        |                       | Shanxi$^b$,                  | Shanxi$^b$,                         |
|        |                       | Guangdong,                  | Guangdong$^a$,                      |
|        |                       | Tibet                        | Tibet$^b$,                          |

Note: a: is compared with Shanxi, and the difference is statistically significant; b: is compared with Guangdong, and the difference is statistically significant.

Similarly, the results of logistic regression analysis exhibited that the region (rural), grade of class, lack of sleep time, heavy learning burden, less than one time per week home visit, lack of exercise, smoking, drinking, and fewer friends were the risk factors for psychological SHS, while females (gender), family, township, seeking help, and extroversion were the protective factors for the occurrence of psychological SHS (Table 3-4).

### Table 3. A multi-factor unconditional logistic regression model of associated factors of psychological SHS

| Variables | Number (%) | OR | AOR | 95% CI Lower | 95% CI Upper | P-value |
|-----------|------------|----|-----|--------------|--------------|---------|
| Area      |            |    |     |              |              |         |
| Guangzhou | 491(33.61) |    |     |              |              | 0.009   |
| Shanxi    | 464(31.76) | 1.908 | 1.887 | 1.239 | 2.874 | 0.003 |
| Tibet     | 506(34.63) | 1.239 | 1.285 | 0.699 | 2.399 | 0.430 |
| Gender    |            |    |     |              |              |         |
| Female    | 825(56.47) | 0.583 | 0.679 | 0.470 | 0.980 | 0.039 |
| Grade     |            |    |     |              |              |         |
| High-I    | 521(35.67) |    |     |              |              | 0.029   |
| High-II   | 536(36.68) | 1.811 | 1.728 | 1.097 | 2.720 | 0.018 |
| High-III  | 404(27.65) | 1.738 | 1.752 | 1.128 | 2.723 | 0.013 |
| Residence |            |    |     |              |              |         |
| Urban     | 465(31.82) |    |     |              |              | 0.037   |
| Rural     | 77(5.27)   | 0.402 | 0.588 | 0.351 | 0.983 | 0.043 |
| Township  | 138(9.45)  | 0.856 | 1.141 | 0.541 | 2.406 | 0.730 |
| County    | 69(4.74)   | 1.391 | 1.450 | 0.772 | 2.723 | 0.248 |
| Suburb            | 712(48.74) | 0.709 | 0.802 | 0.350 | 1.837 | 0.602 |
|-------------------|------------|-------|-------|-------|-------|-------|
| Home visits       |            |       |       |       |       |       |
| No visit          | 238(16.29) | —     | —     | —     | —     | 0.013 |
| 3 or more days    | 205(14.03) | 3.155 | 2.478 | 1.295 | 4.745 | 0.006 |
| 1-2 visit         | 1018(69.68)| 1.759 | 1.410 | 0.757 | 2.627 | 0.279 |
| Sleep time        |            |       |       |       |       |       |
| >8 hours          | 158(10.81) | —     | —     | —     | —     | 0.002 |
| <6 hours          | 1234(84.46)| 11.417| 9.459 | 2.035 | 43.971| 0.004 |
| 6-8 hours         | 69(4.72)   | 6.715 | 5.077 | 1.148 | 22.459| 0.032 |
| Learning burden   |            |       |       |       |       |       |
| Very light        | 307(21.01) | —     | —     | —     | —     | <0.001|
| Light             | 556(38.06) | 0.379 | 0.232 | 0.018 | 2.965 | 0.261 |
| General           | 556(36.69) | 2.074 | 2.084 | 0.828 | 5.244 | 0.119 |
| Heavy             | 40(2.74)   | 2.289 | 2.427 | 1.566 | 3.761 | <0.001|
| Very heavy        | 22(1.51)   | 0.919 | 0.990 | 0.674 | 1.454 | 0.960 |
| Frequency of movement |        |       |       |       |       |       |
| 2-3 hours         | 329(22.52) | —     | —     | —     | —     | <0.001|
| 3 or more times   | 575(39.36) | 2.507 | 2.472 | 1.629 | 3.750 | <0.001|
| No movement       | 557(38.12) | 0.933 | 0.914 | 0.511 | 1.369 | 0.663 |
| Smoking           | 105(7.19)  | 2.202 | 2.138 | 1.170 | 3.906 | 0.013 |
| Drinking          | 246(16.83) | 1.969 | 2.344 | 1.558 | 3.526 | <0.001|
| Seeking help      | 1329(90.96)| 0.386 | 0.378 | 0.227 | 0.630 | <0.001|
| Interpersonal communication |       |       |       |       |       |       |
| >6 and above      | 36(2.46)   | —     | —     | —     | —     | <0.001|
| No.               | 367(25.12) | 14.232| 10.324| 3.902 | 27.314| <0.001|
| 1-2               | 629(43.05) | 2.701 | 2.543 | 1.580 | 4.092 | <0.001|
| 3-5               | 429(29.36) | 1.842 | 1.839 | 1.196 | 2.828 | 0.006 |
| Personal Behaviour| 1040(71.18)| 0.576 | 0.647 | 0.456 | 0.917 | 0.014 |

4. Discussion

This study aimed to distinguish the SHS and its associated influential factors among high school students in three geographic regions of China. The study found that the overall detection rate of SHS was 55.10%, where the detection rates of physical SHS and Psychological SHS were 25.80% and 46.13%. Compared with the previous studies among high school students by using MSQA scale [24,25], their detection rates of SHS symptoms ranged from 27.00% to 75.30%, and the detection rate was 12.40%–in the range of 41.12%, except for the symptoms of the physical SHS which was slightly lower. The results of the above surveys are almost the same as the results of our study, which indicates that the SHS occurrence stages among the high school students were ubiquitous. The detection rate of physical and psychological SHS was lower than the national level (physical SHS-34.60%,...
Psychological SHS-46.84%, and overall detection rate at the national level SHS-53.92% [21]. An earlier study conducted in our study area found that the overall SHS detection rate in urban high school students in Guangzhou City was 38.53% [25]. The detection rate difference might be due to the difference between the survey method and the measurement scale.

Several SHS measuring tools have been established. Additional, a comprehensive and validated tool for SHS stands the Suboptimal Health Status Questionnaire (SHSQ-25) [3], predominantly targeted at the Physiological and Psychological status of people, has been widely applying at the national or international level in different ethnic groups (Asian, African, and Caucasians), which is also a new mechanism to enables people for early intervention in terms of Predictive, Preventive and Personalized Medicine (PPPM) [26–28]. Similarly, MSQA scale evaluates the SHS of adolescents, which is a valid and approved tool in China, which is formulated by Tao et al. [21]. The test-retest reliability, Cronbach alpha (α) coefficient, and split-half reliability coefficient were 0.87, 0.96, and 0.94, respectively, which was conducted among 7104 middle school students [22]. The study of Xing Chao confirmed that MSQA is a credible, effective, and sensitive SHS tool for adolescents. Therefore, to assess the SHS of adolescents, MSQA is a suitable measuring scale; thus, we applied in our study.

The study result showed that the geographical region, rural area, lack of sleep time, heavy learning burden, drinking alcohol, lack of frequent home visit, and eating habit were significant risk factors for SHS, similarly the region (rural), the grade of class, lack of sleep time, heavy learning burden, personal behaviour, less than one time per week home visit, lack of exercise, smoking, and drinking, were risk factors for psychological SHS. Interestingly, only an hour of daily internet access was found to be a protective factor for physical SHS, whereas, seeking help, and extroversion were the protective factors for the psychological SHS. Consisting, Zhao [29] and Hou et al [12], reported that the main physiological problems of middle school students are fatigue, dizziness, gastrointestinal discomfort, and poor sleep tendency. Proper and active exercise, a balanced diet, avoid alcohol, and tobacco habit is the best way to overcome from SHS.

Notably, this study found that surfing the internet for no more than an hour in a day was a protecting factor for SHS for high school students. This finding is supported by a study that long-term internet access, high frequency of internet access, and internet addiction are the significant risk factors for SHS [30], which is consistent with our study. The short-term internet access can alleviate the student’s stressful learning pressure to a certain extent so that their life rhythm can be slowed down.

An earlier study [30] suggested that, in terms of gender, females have their own physiological characteristics, those are more sensitive, delicate as well as the more complex during the physical and psychological changes of adolescence period, thus difficult to guide them at this period, which makes females more likely to have SHS.
Our study also found that SHS was high among female students, which is also supported by the study of Cao H, et al [19] and Yao Y et al [15]. The number of friends or pair groups is a very important influencing factor for the psychological SHS of young students. The results of previous studies [30,31] displayed that the relationship with classmates, the number of friends, misunderstanding between friends of the middle school students had more SHS, which are closely similar to our study. Interpersonal relationships and the number of friends showed a positive relationship with students; in this stage, students are more willing to share their inner world with others, resulting in they can exchange social support. When they encounter difficulties, they can flexibly use the surrounding interpersonal relationships to enhance their confidence, strength, and overcome.

Similarly, poor lifestyle behaviors such as; smoking and drinking are the main influencing factors of Psychological SHS [4]. A study of Lolokote et al reported that significant relationship between SHS and the use of tobacco and alcohol in the college students [9]. Our study also found that smoking and drinking are risk factors for SHS of high school students. A study to investigate the risky health behavior of middle school students reported [31] that smoking behaviors among adolescent students are often accompanied by drinking behavior, by which they show obvious psychological issues such as depression, anxiety, nervousness, and temper, because it has well known that SHS is highly influenced by unhealthy lifestyle [32].

This survey analyzed the status of SHS among high school students in three economic, geographical, cultural, and environmentally different regions of China, including associated factors of SHS, and results provided a holistic picture of both subjective and objective health measures from the perspective of PPPM [12]. PPPM is a new comprehensive approach in the healthcare sector that allows predicting individual predisposition before the onset of the disease, also provide targeted preventive methods, and create personalized treatment procedures tailored to the person [27]. In recent days, treatment for the non-communicable disease (NCD) are executed after disease onset, which is a very much slow approach from the PPPM perspective [12]. Therefore, timely diagnosis and management of SHS in the society is the holistic approach in terms of PPPM.

However, some limitations must be considered when interpreting the findings of this study. This study used a prospective questionnaire survey method, which is difficult to avoid bias and errors caused by differences in understanding an ability among students from different regions or ethnic groups. This was a cross-sectional survey, which did not allow us to assess accurate causality between psychological symptoms and physical SHS. And data was obtained by the self-rating questionnaire, which might have led to information bias. The participants were selected by a convenient sampling method, which leaves the potential for selection bias, and limited generalizability, the relevancy of results to other populations.

5. Conclusions
This study evaluated the SHS of high school students in three regions in China, where SHS was found high in Shanxi, followed by Tibet and Guangzhou. The SHS among females was high than that of males. Rural areas, grades of class, lack of sleep time, heavy study burden, low number of home visits per week, lack of exercise, smoking, drinking, and fewer friends were risk factors for SHS, while, family in townships, seeking help, extroversion person were a protective factor for the occurrence of SHS. Through the comprehensive prevention and control measures of the school and family of the student, promote students to develop good habits, promptly guide various psychological problems and adjust social adaptability, timely detect and treat the sub-health symptoms that have emerged, and effectively prevent and control the student's health.

**Supplementary Materials:** The following supplementary including appendixes files are available online at www.mdpi.com/xxx/s1, Supplementary file 1 (Appendix-1 Youth Sub Health Status Questionnaire, Appendix-2: Introduction to the study locations); Supplementary-2 (Table S1: Indicators of SHS used in questionnaire, Table S2: Basic characteristics of the study groups, Table S3: Distribution of physical SHS and Psychological SHS in different regions, Table S4: The genders score of SHS symptoms, Table S5: A SHS detection rate by gender)

**Author Contributions:** Conceptualization, Gehendra Mahara and Jinxin Zhang; Data curation, Jiazhi Liang; Formal analysis, Gehendra Mahara, Jiazhi Liang and Zhirong Zhang; Funding acquisition, Jinxin Zhang; Investigation, GeQi; Methodology, Gehendra Mahara, Jiazhi Liang, and Zhirong Zhang; Project administration, Qi Ge and Jinxin Zhang; Resources, Qi Ge; Software, Zhirong Zhang; Supervision, Jinxin Zhang; Writing – original draft, Gehendra Mahara; Writing – review & editing, Gehendra Mahara, and Jinxin Zhang.

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