Metabolic syndrome risk in relation to posttraumatic stress disorder among trauma-exposed civilians in Gansu Province, China

Ma LIhua[1, a, d], Zhang Tao[1, b], Ma Hongbin[c], Wang Hui[d], Wei Suwen[d], Jiao Caihong[e], Jiang Xiaolian[f,a,*]

[a] Institute of Emergency Management and Reconstruction in Post-disaster, Sichuan University, Chengdu, PR China
[b] Department of Spine Surgery, The 940 Hospital of joint Logistics Support force of Chinese People's Liberation Army
[c] School of Civil Engineering, Northwest Minzu University, Lanzhou, PR China
[d] The first hospital of Lanzhou University, Gansu Province, PR China
[e] The first hospital of Long Nan city, Gansu Province, PR China
[f] Nursing department, West China Hospital, Sichuan University, Chengdu, PR China

[1] Ma Lihua and Zhang Tao are first co-author to contributed equally for the article.

[*]Corresponding author at: Nursing department, West China Hospital, Sichuan University, Chengdu 610041, PR China
Email address: jhshuoshi@163.com

Abstract

Background: Evidence of the association between posttraumatic stress disorder (PTSD) and metabolic syndrome is increasing; however, its occurrence after traumatic injury and whether there are sex differences in this association remain unknown. This study aimed to explore the association between posttraumatic stress disorder and metabolic syndrome and each of its components by sex in trauma-exposed civilians.

Method: This study included 1456 men and 1411 women who were trauma-exposed and underwent routine health examinations in a community epidemiological investigation. The participants completed the PTSD Check List-Civilian Version (PCL-C) for PTSD and medical examinations to detect metabolic syndrome. Adjustments for age, marriage, exercise, education, cigarette smoking, cancer, stroke, angina, and thyroid disease were performed. The relationship between PTSD and metabolic syndrome and each of its components was analyzed by multiple logistic regression.

Results: In women, PTSD was associated with metabolic syndrome (OR=1.53, 95% CI= 1.01-1.95, *p*=0.047) and the high-density lipoprotein cholesterol component (OR=1.98, 95% CI= 1.04-2.12, *p*=0.002). In men, PTSD was related to the hypertension component of metabolic syndrome (OR=0.54, 95% CI= 0.31-0.92, *p*=0.023). There was also a relationship between PTSD severity and metabolism (OR=1.141, 95% CI= 1.002-1.280, *p*=0.037) in women, and PTSD was inversely associated with the hypertension component (OR=0.54, 95% CI= 0.31-0.92, *p*=0.023) in men.

Conclusions: PTSD was related to metabolic syndrome only in women. We plan to further research the mechanism of sex differences and dyslipidemia.

Keywords: posttraumatic stress disorder, gender, lipid, metabolic syndrome; PTSD checklist-civilian version (PCL-C)

1. Introduction

Posttraumatic stress disorder (PTSD) is a mental disorder that affects approximately 5% of men and 10% of women in the United States [1]. Studies have reported high rates of lifetime exposure to potentially traumatic events among young women (e.g., [2,3]), and women are more likely than men to develop chronic PTSD after exposure to trauma [3,4,5]. People with PTSD experience an excess mortality rate two to three times higher than the general population [6]. Previous research

has demonstrated that PTSD is associated with poor physical health [7], including the presence and severity of cardiovascular disease (CVD), which predicts mortality independent of age, gender, and conventional risk factors [8]. To assist clinicians in identifying and treating patients at increased risk for CVD, the concept of metabolic syndrome has been recognized.

In addition to distressing psychological symptoms, individuals with PTSD are at increased risk of medical health problems. In particular, PTSD substantially increases the risk of CVD and type 2 diabetes (T2D) [9]. Metabolic syndrome is also a cluster of risk factors for cardiovascular disease and type 2 diabetes, such as abdominal obesity, high triglyceride (TG) levels, low high-density lipoprotein cholesterol (HDL) levels, high blood pressure, and high glucose levels [10,11], collectively referred to as cardiometabolic disease, even after controlling for comorbid major depressive disorder (MDD), which may also increase this risk [12]. Obesity and insulin resistance are proposed core mechanisms for the development of metabolic syndrome, and lipid profiles are known to be associated with both obesity and insulin resistance [9].

One previous meta-analysis attempted to quantify the risk of metabolic syndrome among people with PTSD; they found that people with PTSD have an increased risk of developing metabolic syndrome compared with the general population (odds ratio [OR] 1.37 [95% CI=1.03-1.82; n=528]) [13]. While helpful, a range of questions remain regarding which differences exist by sex. The present research explored the association between PTSD and metabolic syndrome and its components in a sample of Chinese trauma-exposed civilians who participated in a health screening program. There have been reports in the literature that sex differences are related to PTSD, but we aimed to analyze men and women separately. We hypothesized that PTSD and metabolic abnormalities are associated and that there are sex differences in this association.

2. Methods

2.1. Patient population

A total of 2876 participants completed the study from February 2016 to September 2017. Multistage stratified cluster random sampling was used for this study. First, according to the following order, random selection was performed by prefecture-level city, administrative county, township administrative and administrative village in Gansu Province (see definition in Table 1). Participants underwent routine health examinations at the First Hospital of Lanzhou University. A total of 1456 men and 1411 women aged 16 to 90 years old completed the data on each scale of

PTSD and metabolic syndrome.

2.2. Measures

2.2.1. Demographic information

The sociodemographic characteristics included gender, ethnicity, age, family economic status, and housing situation.

2.2.2. Trauma Life Event Questionnaire (TLEQ)

Previously, potential traumatic events in participants were assessed using TLEQ [14]. This brief questionnaire was used to survey a wide range of potentially traumatic events, such as physical assault, motor vehicle accidents, combat, and sexual or drug abuse. These traumatic events were described in behavioral terms based on the Diagnostic and Statistical Manual of Mental Disorders 4th edition-revised (DSM-IV) PTSD criterion [14]. The TLEQ has good reliability and good concurrent and predictive validity [14].

2.2.3. Assessment of PTSD

The PTSD checklist-civilian version (PCL-C) was used to assess the severity of PTSD symptoms. This scale is one of the most frequently used and reliable tools to evaluate PTSD [15, 16].

This scale comprises 17 items; it is a standardized self-report rating scale and contains questions on three main aspects of PTSD symptoms: re-experiencing (RE, 5 items), avoidance (AV, 7 items), and arousal symptoms (AR, 5 items). The intensity and frequency of PTSD symptoms are rated as 5 levels, from 1 to 5, representing none to very severe. Total PTSD scores were calculated by summing the scores for all items, which ranged from 17 to 85, with higher scores indicating more severe PTSD symptoms. In China, the score of 50 has been proven to be the optimal cutoff for diagnosing PTSD [17]. If a participant's score was $\geq$50, the patient was diagnosed with PTSD. Cronbach's alpha coefficients from published research ranged from 0.80 to 0.91 [18, 19]. In this research, the Cronbach's alpha coefficient for the total scale was 0.87, and the internal consistencies of the RE, AV and AR subscales were 0.81, 0.80 and 0.80, respectively.

2.2.4. Assessment of metabolic syndrome

According to the Adult Treatment Panel (ATP) III guidelines criteria [20], metabolic syndrome was defined as meeting at least 3 of the following 5 criteria: (1) abdominal obesity: WC of >90 cm

for men and >85 cm for women; (2) fasting glucose: ≥110 mg/dL; (3) HDL cholesterol level: <50 mg/dL for women and <40 mg/dL for men; (4) diastolic blood pressure ≥85 mmHg and systolic blood pressure ≥130 mmHg; and (5) triglycerides ≥150 mg/dL.

2.3. Procedures

Data collection comprised two sessions: laboratory assessment and survey using a questionnaire. Participants were asked to refrain from eating for 12 h, strenuous exercise and caffeine for 3 h, and smoking for 3 min prior to beginning the health examination. With participants who met these restrictions, we conducted the laboratory assessment; otherwise, those who were noncompliant had only one chance to reschedule. In general, the objectives of this study were to remind participants to effectively promote restrictions. This session began at 8:00 am due to the assessment of some indicators of fasting blood lipids. After taking blood, a light breakfast snack (e.g., bread, milk or eggs) was provided. Before the BP assessment, participants sat quietly for at least 20 min. We obtained mercury sphygmomanometer-determined diastolic and systolic measurements, which were performed 3 times at 2 min intervals on the dominant arm. After the physical examination (i.e., height, lipids, BP, WC and weight) was completed, the survey questionnaires were given. The laboratory examination results were explained by psychiatry and endocrinology doctors and assistants.

2.4. Statistical analyses

Statistical analyses in this study data were performed using SPSS 21.0, and statistical significance was defined as $p < 0.05$.

Differences in metabolic characteristics and social demographics between patients with and without PTSD were assessed based on a PCL-C score >50 [21].

Categorical variables were analyzed using the chi-square test. For normally distributed continuous variables, a two-tailed Student's *t*-test was used, and for continuous variables that were not normally distributed, a Mann-Whitney U test was used.

Associations between PTSD and metabolic syndrome and each of its components were assessed with logistic regression models. First, metabolic syndrome and each of its components as individual outcome variables and PTSD as a dichotomous independent variable were used in a

single regression analysis. Covariates such as sex, age, cigarette smoking, alcohol or drug use, education, exercise, cancer, stroke, angina, and thyroid disease were added in multiple regression analyses. To determine whether the cutoff scores of PTSD defining metabolic syndrome influenced the association, we also used linear regression to analyze the association between PTSD and the total score of metabolic syndrome components and each continuous metabolic component. Logarithmic transformations were used for non-normal distribution.

We also used the total score as a continuous variable and conducted multiple logistic regression to determine whether there was a graded relationship between PTSD severity and metabolic syndrome.

3. Results

3.1. Demographic and metabolic characteristics

PTSD symptoms were present in 201 (7.01%) patients, including 58 (2.03%) men and 143 (4.98%) women. With regard to trauma history, event type and prevalence are shown in Table 2. By comparing non-PTSD participants with participants with PTSD, logistic regression identified the following independent factors for having PTSD: female sex [odds ratio (OR)=2.718, 95% confidence interval (CI)=1.985-3.723], age 16-35 years (OR=1.728, 95% CI=1.152-2.592), unemployment (OR=1.418, 95% CI=1.061-1.894), less than six years of education (OR=2.014, 95% CI=1.423-2.851), low family income (OR=1.728, 95% CI=1.117-2.672), current smoking (OR=1.835, 95% CI=1.226-2.747), and exercise 1-2 times/week (OR=1.793, 95% CI=1.317-2.440), with adjustments for history of stroke, angina and thyroid disease. All respondent's detailed baseline demographic characteristics are shown in Table 3.

Table 4 shows that the association between metabolic syndrome and PTSD. In all, 19.4% of participants with PTSD and 13.7% of participants without PTSD had metabolic syndrome, and the difference was statistically significant (p = 0.025). More participants with PTSD met HDL and glucose criteria, but fewer participants with PTSD met criteria for hypertension.

Further statistical analysis by sex was conducted. In women, PTSD was significantly associated with metabolic syndrome (17.5% vs. 11.6%, p=0.043), each component of metabolic syndrome, and all the individual components. However, there was no significant association between PTSD and metabolic syndrome in men, with the exception of hypertension, which was more prevalent in the nondepressed group.

Regarding the continuous components of metabolic syndrome, with the exception of systolic blood pressure, all other factors were associated with PTSD in women. However, the statistical analysis showed that in men, PTSD was related to a smaller waist circumference, higher TG levels, and lower diastolic blood pressure compared with non-PTSD men.

3.2. Association between PTSD and metabolic syndrome and each of its components

In all participants, PTSD was positively associated with metabolic syndrome and glucose components. When adjusted for confounding factors, such as sex, the analysis showed that only the HDL component was significantly associated with PTSD.

Stratification by sex demonstrated different types of associations. PTSD was positively associated with metabolic syndrome and each of its components in women, but PTSD was inversely associated only with the hypertension component in men. After adjusting for additional factors, including age, marriage, cigarette smoking, exercise, education, cancer, angina, stroke, and thyroid disease, PTSD was also associated with metabolic syndrome (OR=1.53, 95% CI= 1.01-1.95, p=0.047) and the prevalence of the HDL component (OR=1.98, 95% CI= 1.04-2.12, p=0.002) in women, and PTSD was inversely associated with the hypertension component (OR=0.54, 95% CI= 0.31-0.92, p=0.023) in men. In women, after adjusting for additional factors, including menopause and oral contraceptive/hormone treatment, PTSD was still associated with metabolic syndrome and the HDL component, which showed significant differences (OR=1.44, 95% CI= 1.12-1.76, p=0.047 and OR=1.99, 95% CI= 1.07-2.74, p=0.005, respectively). Details of the data analysis are shown in Table 5.

We also analyzed the independent association between PTSD and continuous components of metabolic syndrome. After adjusting for factors including age, marriage, cigarette smoking, exercise, education, cancer, angina, stroke, and thyroid disease, PTSD was negatively associated with waist circumference (β= -0.033, p=0.05), systolic blood pressure (β= -0.037, p=0.002) and diastolic blood pressure (β= -0.021, p=0.032) in men, and in women, they were positively associated with waist circumference (β= 0.021, p=0.038) and log-transformed TG levels (β= 0.025, p=0.003), and they were negatively associated with HDL levels (β= -0.022, p=0.021). The detailed data analysis is shown in Table 6.

We further conducted a linear regression analysis between PTSD and the number of metabolic syndrome components, adjusting for age, marriage, cigarette smoking, exercise, education, cancer, angina, stroke, and thyroid disease, by sex. The data analysis showed that PTSD was significantly associated with the number of metabolic syndrome components in women (β= 0.027, *p*=0.001), but there was no significant association in men (β= -0.013, *p*=0.08).

3.3. Relationship between PTSD severity and metabolic syndrome

We used the total score as a continuous variable and adjusted for age, marriage, cigarette smoking, exercise, education, cancer, angina, stroke, and thyroid disease. PTSD severity was compared with metabolism in women in multiple logistic regression analysis to determine whether there was a graded relationship between PTSD severity and metabolism (OR=1.141, 95% CI= 1.002-1.280, *p*=0.037); furthermore, the association remained after adjustment for additional factors, including menopause and oral contraceptive/hormone treatment (OR=1.112, 95% CI= 1.003-1.221, *p*=0.046). However, there was no significant association between PTSD severity and metabolic syndrome (OR=1.101, 95% CI= 0.908-1.249, *p*=0.071) in men.

3.4. Sensitivity analysis

We excluded 121 men and 76 women who were taking antidepressants, anxiolytics, anti-schizophrenia medication or sleep medication or who were missing data for these variables to analyze whether psychotropic drug therapy might influence the research results. However, we found the same result, namely, that the association between PTSD and metabolic syndrome was significant (OR=1.33, 95% CI= 1.11-1.56, *p*=0.036).

4. Discussion

PTSD was associated with metabolic syndrome and with the number of metabolic syndrome components only in women after adjusting for some confounding factors. Women with PTSD had an approximately 1.62-fold higher risk of metabolic syndrome than women without PTSD, and we found an association between PTSD severity and the risk of metabolic syndrome. In each component, the HDL and glucose components were associated with PTSD after adjusting for confounding factors in women, and the hypertension component was inversely associated with PTSD in men. Linear regression achieved the same results, showing that TG and waist circumference were positively associated with PTSD in women and negatively associated with

PTSD in men.

In previous studies, a major finding was that the association between PTSD and metabolic syndrome was confined to women [22, 23, 24, 25]. However, there are still other studies that have shown that the association is confined to men [9, 26, 27]. These discrepancies may be explained by different research methods and designs or sample selection. Previous studies that reported the association was confined to women [22, 23, 24, 25] included a wide age range, whereas most studies [9, 26, 27] that reported the association in men included young military veterans and a narrower age range than did our research. Esther M. Blessing, whom reported the association only in men, used a sample with an average age of 32.7 years old, which is younger than our sample. In women, the LDL component was associated with PTSD in both logistic and linear regression, whereas TG and waist circumference were associated with PTSD in linear regression after adjusting for some confounding factors. The discrepancy between logistic and linear regression may be explained by the different cutoffs and definitions of each component. Although we consider both logistic and linear regression to be reasonable statistical analysis methods, linear regression is limited because the value of each component may have been directly affected by medical treatment. However, PTSD was associated with HDL, TG and waist circumference, and this association has substantial supportive evidence in previous research [28].

PTSD was inversely associated with hypertension in men. A few studies with smaller samples have shown a positive relationship between hypertension and PTSD in both men and women; further investigation is needed [29]. A previous study reported that depression syndrome is inversely related to hypertension in men [30], a finding that is similar to ours. Logistic regression showed no statistically significant association between PTSD and waist circumference in men; however, in linear regression, waist circumstance is similar to hypertension and is negatively associated with PTSD in men; thus, we should be cautious in explaining the results..

There are several factors that were related to sex differences. First, physiological hormones may be an influence for both men and women. For example, in women, menopause syndrome and use of related medications are known to have effects on PTSD [22] and on the risk of metabolic syndrome [31]. After adjusting for all possible confounding factors, PTSD is still associated with metabolism in women, so the sex difference cannot be explained by hormonal factors alone. At the same time, participants' lifestyle should be considered. Cigarette smoking and lack of exercise are

known to influence PTSD, and the patterns of these behaviors differed between men and women [32]. However, after we adjusted for these lifestyle factors, differences between PTSD and metabolism in women still existed. Another possible factor may be related to the use of self-reports to assess PTSD. PTSD is reported to be more common in women [1], which is similar to the results of our study (3.98% of men and 10.13% of women). Another possible reason may be that men underreported the severity of PTSD, potentially resulting in a classification bias.

Insulin resistance, one of the important pathologies of metabolic syndrome [33], may be an underlying factor in the association between PTSD and metabolic syndrome. Insulin resistance is known to be associated with PTSD in young military veterans [9], which was significantly different than the association between PTSD and metabolic syndrome in our study. Farr et al. reported that increased PTSD symptom severity in a mixed gender older civilian population predicted mild decreases in insulin sensitivity [34].

Previous studies showed that another potential mechanism is inflammation, which is associated with PTSD [35, 36]. HDL particles are central to reverse cholesterol transport, which is different from other cholesterol. HDL transports excess cholesterol stored in peripheral cells to the liver for excretion [37, 38]. Therefore, HDLs have antiatherogenic properties that may be related to their involvement in cholesterol homeostasis [39]. Sympathetic overactivity and vagal withdrawal induce a proinflammatory state and increase the production of inflammatory cytokines such as interleukin-6 (IL-6) [40]. Through this process, serum amyloid A (SAA) is produced, which replaces Apo1 as the apolipoprotein in HDL-C particles. As a result, HDL-C particles break down, and the decrease in HDL-C concentration is due to increased IL-6 production following sympathetic overactivation [41].

The association between the PCL-C score and metabolic syndrome in women has shown that PTSD severity may be important in assessing the risk of metabolic syndrome. A few studies have shown similar results [42]. This finding emphasizes the importance of evaluating not only the prevalence of PTSD but also the severity of metabolic syndrome.

There are several limitations to this research. First, this research is a cross-sectional study; thus, causality cannot be determined. It is possible that PTSD is a risk factor for metabolic syndrome or that metabolic syndrome is a risk factor for PTSD [43]. However, a meta-analysis has provided increased evidence that the association is bidirectional [13]. Second, this study used the

self-reported scale PCL-C and did not use the Clinician-Administered PTSD Scale (CAPS); thus, the diagnosis of PTSD did not occur through clinical psychiatrists. However, we used a cutoff score validated for the Chinese population, and previous studies have shown that this approach has high sensitivity and specificity for diagnosing PTSD in civilians [17]. Third, the sample in this study only enrolled people of Han ethnicity in Gansu Province in China; thus, other provinces and other ethnic civilians should be considered. Fourth, low-income civilians may have been more likely to take advantage of this free examination; thus, our sample selection may have selection biases.

Despite these limitations, our study has major advantages. First, we studied a large number of civilians, including a wide age range. Our study sample provided sufficient statistical power, and generalization to similar populations is reasonable. Second, previous studies may have bias regarding the association between PTSD and metabolic syndrome by sex, but our study showed no association between PTSD and metabolic syndrome in men; however, a significant association between PTSD and metabolic syndrome was observed in women. Third, each of the metabolic syndrome components was used to determine whether any specific components were associated with PTSD. The lipid components may play an important role in the development of metabolic syndrome, particularly in women, and this aspect needs further research.

5. Conclusion

In conclusion, our research showed that PTSD was associated with metabolic syndrome in women after adjusting for other confounding factors. The results of this study especially emphasize that for females diagnosed with PTSD, screening with laboratory evaluations is recommended, including lipid profiles, as metabolic syndrome can be comorbid with PTSD. Further longitudinal studies with multiethnic samples and evaluation of specific mechanisms (especially dyslipidemia) should consider sex differences.

Potential conflict of interest

All other authors report that there are no financial relationships with commercial interests.

Submission declaration and previous presentation

We certify that the submission is original work and is not under review at any other journal.

Contributors

All authors contributed to the analysis, interpretation of results and drafting the critical review of

the manuscript. All authors reviewed and approved the final version of the manuscript.

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