Observational Study

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

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Abstract

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 posttraumatic stress disorder (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.

In women, PTSD was associated with metabolic syndrome (OR=1.53, 95% CI=1.01–1.95, P=.047) and the high-density lipoprotein cholesterol component (OR=1.98, 95% CI=1.04–2.12, P=.002). In men, PTSD was related to the hypertension component of metabolic syndrome (OR=0.54, 95% CI=0.31–0.92, P=.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=.023) in men.

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

Abbreviations: ATP = adult treatment panel, CI = confidence interval, CVD = cardiovascular disease, DSM-IV = Diagnostic and Statistical Manual of Mental Disorders 4th edition-revised, HDL = high-density lipoprotein, MDD = major depressive disorder, OR = odds ratio, PCL-C = check list-civilian version, PTSD = posttraumatic stress disorder, SD = standard deviation, T2D = type 2 diabetes, TG = triglyceride, TLEQ = trauma life event questionnaire, WC = waist circumference.

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

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Key Points

- 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.
- 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.

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,[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 2 to 3 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. Metabolic syndrome has also been associated with PTSD. 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. 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. Inclusion criteria:

(a) Age 16 to 90 years;
(b) if participants with any traumatic exposure, then we surveyed who were PTSD.

Criteria for exclusion were:

(a) history of alcohol dependence within the past 8 months;
(b) history of drug abuse or dependence (except nicotine dependence) within the past year;
(c) exposure to recurrent trauma or exposure to a traumatic event within the past 3 months;
(d) prominent suicidal or homicidal ideation;
(e) neurologic disorder or systemic illness affecting central nervous system function.

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 minimal score for diagnosing PTSD.[17] If a participant's score was ≥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 hours, strenuous exercise and caffeine for 3 hours, and smoking for 30 minutes (current smoker including 657 participants) 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 minutes. We obtained mercury sphygmomanometer-determined diastolic and systolic measurements, which were performed 3 times at 2 minutes 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.[22]

2.4. Statistical analyses

Statistical analyses in this study data were performed using SPSS 21.0, and statistical significance was defined as $P<.05$.

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. To determine whether the possible confounding factors are related with PTSD, we are adjusted related factors in multiple regression analyses. 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.

2.5. Ethical issues

The study was reviewed and approved by the institutional review board of the First Hospital of Lanzhou University. Prior to interviews, the interviewers explained the survey and the opportunity for participation to each civilian.

3. Results

3.1. Demographic and metabolic characteristics

The total population (11500), traumatic event prevalence rate (2867/11500) is 24.93% and prevalence of PTSD (201/11500) is 1.75%. 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 Figure 1. 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 to 35 years (OR = 1.728, 95% CI = 1.152–2.592), unemployment (OR = 1.418, 95% CI = 1.061–1.894), less than 6 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 to 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 Figure 2.

Figure 3 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 = .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

Type of events	N	%
Physical assault/ abuse/ victim of domestic violence	659	23%
Sudden unexpected death of a loved relative	573	20%
Sexual assault/ abuse	487	17%
Witnessing violence	344	12%
Other traumas (e.g., jailed/ lost in foreign country or life threatening accidents requiring hospitalization)	230	8%
Animal damage (e.g., dog/ cat/ snake and so all)	115	4%
Motor vehicle accident	115	4%
Nature disaster	115	4%
stalking	115	4%
Abortion	57	2%
Sexual harassment	57	2%

N=Number

Figure 1. N = Number.

	Classification(N=2867)	x^2	*p*	PTSD (201) n (%)	Not PTSD (2666) n (%)	OR	95%CI
Gender	Male(1456)	38.853	<0.001[a]	58(28.85)	1398(52.44)	1	——
	Female(1411)			143(71.15)	1268(47.56)	2.718[a]	1.985-3.723
Age	55+(607)			33(16.41)	574(21.53)	1	——
	36-54(1131)	6.979	0.008[a]	66(32.84)	1065(39.95)	1.078[a]	0.701-1.657
	16-35(1129)			102(50.75)	1027(38.52)	1.728[a]	1.152-2.592
Occupation	Employment(1458)	5.584	0.018	86(42.79)	1372(51.46)	1	——
	Unemployment (1409)			115(57.21)	1294(48.54)	1.418	1.061-1.894
Education	>12(859)			74(36.82)	785(29.44)	1	——
(years)	6~12(1252)	15.603	<0.001[a]	64(31.84)	1188(44.56)	1.371	0.965-1.948
	<6(765)			63(31.34)	693(26.00)	2.014	1.423-2.851
Family income	High(>¥50,000/year)(1199)			84(41.79)	1115(41.82)	1	——
	Median(¥10,000/year-50,000/year)(1380)	6.072	0.048	87(43.28)	1293(48.50)	1.543	0.996-2.393
	Low(<¥10,000/year)(288)			30(14.93)	258(9.68)	1.728[a]	1.117-2.672
Cigarette smoking	Current non-smoker (2208)	8.7	0.003	172(85.57)	2036(76.37)	1	——
	Current smoker (659)			29(14.43)	630(23.63)	1.835	1.226-2.747
Exercise	≥5/week (394)			26(12.94)	368(13.81)	1	——
	3-4/week (1503)	14.021	0.001	83(41.29)	1420 (53.26)	1.483	0.944-2.331
	1-2/week (970)			92(45.77)	878(32.93)	1.793[a]	1.317-2.440
Cancer (28)		2.177	0.140	4(1.99)	24(0.90)	2.235	0.768-6.506
Stroke(15)		7.293	0.007	4(1.99)	11(0.41)	4.901[a]	1.546-15.523
Angina(36)		4.813	0.028	6(2.98)	30(1.12)	2.704[a]	1.112-6.574
Thyroid disease(69)		5.739	0.017	10(4.97)	59(2.21)	2.313[a]	1.165-4.595

OR, odds ratio; CI, confidence interval.

Abbreviations: SD=standard deviation

[a] Two-tailed Student's t-test for normally distributed variables, Mann-Whitney U-test for skewed variables, and chi-square test for categorical variables. Boldface p-values are significant at α=0.05

Figure 2. *OR, odds ratio; CI, confidence interval.* SD = standard deviation. [a]Two-tailed Student's *t* test for normally distributed variables, Mann-Whitney *U* test for skewed variables, and chi-square test for categorical variables. Boldface *P* values are significant at α = 0.05.

syndrome (17.5% vs 11.6%, *P* = .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.

Department	Total		p-Value [a]	Men		p-Value [a]	Women		p-Value [a]
	PTSD	Not PTSD		PTSD	Not PTSD		PTSD	Not PTSD	
	n=201	n=2666		n=58	n=1398		n=143	n=1268	
Metabolic syndrome [b], n(%)	39(19.4)	366(13.7)	0.025	14(24.1)	219(15.7)	0.088	25(17.5)	147(11.6)	0.043
Waist circumference component [c], n(%)	57(28.3)	709(26.5)	0.568	16(27.5)	438(31.3)	0.547	41(28.6)	271(21.4)	0.047
TG component [d], n(%)	52(25.8)	685(25.6)	0.956	22(25.8)	542(38.8)	0.898	30(16.8)	182(14.3)	0.037
HDL component [e], n(%)	46(22.9)	424(15.8)	0.010	15(25.8)	273(19.5)	0.238	31(21.6)	151(11.9)	0.001
Hypertension component [f], n(%)	59(26.4)	561(20.9)	0.036	23(39.6)	364(26.0)	0.023	36(25.2)	197(15.5)	0.003
Glucose component [g], n(%)	54(26.8)	420(15.7)	<0.001	18(31.0)	305(21.8)	0.101	36(25.2)	149(13.3)	0.016
Waist circumference, mean ± SD	82.1±8.2	83.4±7.9	<0.001	85.8±7.6	86.7±6.3	0.019	81.0±7.9	79.8±7.5	<0.001
TG, median, IQR, mg/dL	86.1,58	89,63	0.012	110.4,78	108,70	0.034	79,50	74,44	<0.001
HDL, mean ± SD, mg/dL	57.1±13.2	55.7±12.8	<0.001	51.4±12.1	51.2±11.1	0.75	58.9±13.1	60.3±13.4	0.044
Systolic blood pressure, mean ± SD, mmHg	113.4±13.4	114.9±13.1	<0.001	116.2±13.8	117.3±12.7	0.004	112.4±16.1	111.3±15.2	<0.001
Diastolic blood pressure, mean ± SD, mmHg	72.1±11.2	74.1±12.3	<0.001	76.1±10.1	77.8±10.5	0.003	71.0±11.7	70.2±10.2	0.016
Fasting glucose, median, IQR, mg/dL	93.1,13	93.0	0.009	95.4,11	96.1,12	0.35	92,14	91,10	<0.001
Medication									
Antilipidemic medication	7(3.5)	190(7.1)	0.049	1(1.7)	129(9.1)	0.051	6(4.2)	61(4.8)	0.893
Antidiabetic medication	6(3.0)	69(2.6)	0.734	2(3.4)	18(1.2)	0.163	4(2.8)	51(4.0)	0.437
Antitypertensive medication	24(11.9)	314(11.7)	0.048	6(10.3)	216(15.3)	0.335	18(12.6)	98(7.7)	0.045

Abbreviations: SD=standard deviation, TG=triglyceride, IQR=interquartile range, HDL=high-density lipoprotein cholesterol.

[a] Two-tailed Student's t-test for normally distributed variables, Mann-Whitney U-test for skewed variables, and chi-square test for categorical variables. Boldface p-values are significant at α=0.05

[b] National Cholesterol Education Program Adult Treatment Panel III (ATP III) criteria for metabolic syndrome were used with the modified waist circumference criteria from the China Society for the study of Obesity.

[c] Waist circumference >90cm for men and >85cm for women

[d] Serum TG≥150 mg/dL or antilipidemic medication

[e] Serum HDL<40 mg/dL for men and 50 mg/dL for women

[f] Systolic blood pressure ≥130 mmHg or diabetic blood pressure≥85 mmHg or antihypertensive medication

[g] Fasting plasma glucose≥110 mg/dL or antidiabetic medication

Figure 3. HDL = high-density lipoprotein cholesterol, IQR = interquartile range, SD = standard deviation, TG = triglyceride. [a]Two-tailed Student's *t* test for normally distributed variables, Mann-Whitney *U* test for skewed variables, and chi-square test for categorical variables. Boldface *P* values are significant at $\alpha = 0.05$. [b]National Cholesterol Education Program Adult Treatment Panel III (ATP III) criteria for metabolic syndrome were used with the modified waist circumference criteria from the China Society for the study of Obesity. [c]Waist circumference >90 cm for men and >85 cm for women. [d]Serum TG ≥ 150 mg/dL or antilipidemic medication. [e]Serum HDL<40 mg/dL for men and 50 mg/dL for women. [f]Systolic blood pressure ≥130 mmHg or diabetic blood pressure ≥85 mmHg or antihypertensive medication. [g]Fasting plasma glucose ≥110 mg/dL or antidiabetic medication.

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 = .047) and the prevalence of the HDL component (OR = 1.98, 95% CI = 1.04–2.12, P = .002) in women, and PTSD was inversely associated with the hypertension component (OR = 0.54, 95% CI = 0.31–0.92, P = .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 = .047 and OR = 1.99, 95% CI = 1.07–2.74, P = .005, respectively). Details of the data analysis are shown in Figure 4.

We also analyzed the independent association between PTSD and continuous components of metabolic syndrome. Whether the factors Cardiovascular disease and thyroid are related with PTSD, which are not reported by pertinent literature. So, Cardiovascular disease and thyroid after controlling for all possible confounding factors are necessary. 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 = .05), systolic blood pressure (β = −0.037, P = .002) and

	Metabolic syndrome		Waist circumference component		TG component		HDL component		Hypertension		Glucose component	
	OR (95%)	*p*-value[a]	OR (95%)	*p*-value[a]	OR (95%)	*p*-value[a]	OR (95%)	*p*-value[a]	OR (95%)	*p*-value[a]	OR (95%)	*p*-value[a]
total												
Model 1	1.51 （1.05-2.18）	**0.025**	1.09 （0.79-1.50）	0.586	1.01 （0.73-1.40）	0.956	0.64 （0.45-0.90）	**0.010**	0.71 （0.52-0.98）	**0.036**	1.70 （1.23-2.36）	**<0.001**
Model 2	1.50 （0.98-2.02）	0.071	1.03 (0.83-1.23)	0.711	1.22 (0.88-1.56)	0.983	0.94 (0.88-1.00)	**0.031**	0.84 (0.78-0.90)	0.57	1.26 (1.12-1.40)	0.37
Men												
Model 1	1.71 （0.92-3.18）	0.088	0.84 （0.46-1.51）	0.547	0.97 （0.56-1.66）	0.898	1.44 (0.79-2.63)	0.238	0.54 (0.31-0.92)	**0.023**	1.61 (0.91-2.85)	0.10
Model 2'	1.64 (0.85-2.43)	0.065	0.81 (0.42-1.20)	0.485	0.94 (0.47-1.41)	0.794	1.33 (0.70-1.96)	0.352	0.53 (0.34-0.90)	**0.026**	1.66 (0.93-2.39)	0.08
Women												
Model 1	1.62 (1.02-2.57)	**0.043**	1.48 (1.01-2.18)	**0.047**	1.58 (1.03-2.44)	**0.037**	2.05 (1.33-3.16)	**0.001**	1.83 (1.22-2.75)	**0.003**	2.53 (1.67-3.83)	**<0.001**
Model 2'	1.53 (1.01-1.95)	**0.047**	1.26 (0.78-1.74)	0.283	1.48 (1.15-1.81)	0.146	1.98 (1.24-2.72)	**0.002**	1.76 (1.13-2.39)	0.08	2.37 (1.61-3.13)	0.18
Model 3	1.44 (1.12-1.76)	**0.047**	1.29 (0.80-1.78)	0.196	1.47 (1.13-1.81)	0.158	1.98 (1.22-2.74)	**0.005**	1.74 (1.11-2.37)	0.14	2.43 (1.64-3.52)	0.08

Model 1: No adjustment.

Model 2: Adjusted for sex, marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, and thyroid disease.

Model 2': Adjusted for marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, and thyroid disease.

Model 3: Adjusted for sex, marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, thyroid disease, menopause, and oral contraceptive/ hormone treatment.

Abbreviations: OR=odds ratio CI=confidence interval, TG=triglyceride, HDL= high-density lipoprotein cholesterol

[a] Boldface *p*-values are significant at α=0.05

Figure 4. Model 1: No adjustment. Model 2: Adjusted for sex, marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, and thyroid disease. Model 2': Adjusted for marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, and thyroid disease. Model 3: Adjusted for sex, marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, thyroid disease, menopause, and oral contraceptive/ hormone treatment. CI = confidence interval, HDL = high-density lipoprotein cholesterol, OR = odds ratio, TG = triglyceride, [a]Boldface *P* values are significant at α = 0.05.

diastolic blood pressure (β = −0.021, *P* = .032) in men, and in women, they were positively associated with waist circumference (β = 0.021, *P* = .038) and log-transformed TG levels (β = 0.025, *P* = .003), and they were negatively associated with HDL levels (β = −0.022, *P* = .021). The detailed data analysis is shown in Figure 5.

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* = .001), but there was no significant association in men (β = −0.013, *P* = .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* = .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* = .046). However, there was no significant association between PTSD severity and metabolic syndrome (OR = 1.101, 95% CI = 0.908–1.249, *P* = .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* = .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.

	Waist circumference		Log TG		HDL		Systolic blood pressure		Diastolic blood pressure		Log Glucose	
	β	*p*-value [a]	β	*p*-value [a]	β	*p*-value [a]	β	*p*-value [a]	β	*p*-value [a]	β	*p*-value [a]
total												
Model 1	-0.078	**0.002**	-0.022	**0.012**	0.031	**<0.001**	-0.038	**<0.001**	-0.032	**<0.001**	-0.011	**0.031**
Model 2	0.006	0.45	0.013	**<0.001**	-0.012	0.063	-0.009	0.25	-0.003	0.51	0.006	0.30
Men												
Model 1	-0.034	**0.012**	0.011	**0.004**	0.004	0.89	-0.034	**0.004**	-0.023	**0.004**	<0.001	0.96
Model 2’	-0.033	0.05	**0.010**	0.06	0.007	0.43	-0.037	**0.002**	-0.021	**0.032**	0.002	0.76
Women												
Model 1	0.058	**0.003**	0.049	**<0.001**	-0.031	**<0.001**	0.016	**0.046**	0.017	**0.024**	0.027	**0.002**
Model 2’	0.019	**0.044**	0.025	**0.002**	-0.021	**0.021**	<0.001	0.98	0.002	0.73	0.016	014
Model 3	0.021	**0.038**	0.025	**0.003**	-0.022	**0.021**	-0.002	0.63	-0.001	0.92	0.020	0.06

a

Model 1: No adjustment.

Model 2: Adjusted for sex, marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, and thyroid disease.

Model 2’: Adjusted for marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, and thyroid disease.

Model 3: Adjusted for sex, marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, thyroid disease, menopause, and oral contraceptive/ hormone treatment.

Abbreviations: OR=odds ratio CI=confidence interval, TG=triglyceride, HDL= high-density lipoprotein cholesterol

[a] Boldface *p*-values are significant at α=0.05

Figure 5. Model 1: No adjustment. Model 2: Adjusted for sex, marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, and thyroid disease. Model 2’: Adjusted for marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, and thyroid disease. Model 3: Adjusted for sex, marriage, age, cigarette smoking, exercise, education, angina, cancer, stroke, thyroid disease, menopause, and oral contraceptive/ hormone treatment. CI=confidence interval, HDL=high-density lipoprotein cholesterol, OR=odds ratio, TG=triglyceride. [a]Boldface *P* values are significant at α=0.05.

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]

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.[35] 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.[36] 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.

The prevalence estimates can shift over time and PTSD symptoms may gradually fade over time. This project was a cross-sectional study, we only get the patients who are suffering from PTSD or not suffering from PTSD after trauma-exposure. To determine whether the patients had PTSD at 30 days, one year, two years, or a lifetime was need to further conducted investigation.

Moreover, the audiences may take interest in rough time frame of development of metabolic syndrome after trauma exposure in the patients who are diagnosed as PTSD. During investigating, we found that some elderly PTSD had metabolic syndrome before the wound exposed and most of the rural PTSD after the wound exposed, who have not conducted the metabolic syndrome examination. These PTSD patients found that they had the metabolic syndrome at first time during free examination, which may be related to rural poor economic conditions and people lacking of health consciousness. Thus, the data on period of time (months or years; average and median values) between trauma-exposure and PTSD/metabolic syndrome diagnosed have not provided.

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.

Author contributions

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