Posttraumatic Stress Disorder and Risk of Obesity:
Systematic Review and Meta-Analysis

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ABSTRACT

Objective: To examine the association between posttraumatic stress disorder (PTSD) and obesity in the literature to date.

Data Sources: We systematically searched PubMed, Embase, Scopus, Web of Science, and ProQuest from database inception until September 2013. Search phrases combining the terms *Obesity* and *Post-Traumatic Stress Disorder* were used.

Study Selection: We selected observational studies estimating obesity prevalence in samples of people with PTSD, as well as in comparison groups without PTSD.

Data Extraction: Obesity rates as well as demographic, clinical, and methodological variables were extracted from each publication or obtained directly from its authors.

Results: A total of 113, 395, 59, 115, and 400 records were generated from PubMed, Embase, Scopus, Web of Science, and ProQuest, respectively. Thirteen studies were eligible according to inclusion criteria. The pooled crude odds ratio (OR) and 95% confidence interval (CI) for obesity among people with PTSD, based on 589,781 subjects, was 1.55 (1.32–1.82). A large heterogeneity was found (I^2 = 90%), and risk of publication bias was statistically significant (P = .002). However, subgroup and sensitivity analyses including only studies with most accurate methods to assess obesity (OR = 1.35; 95% CI,1.05–1.74; I^2 = 47%) and PTSD (OR = 1.82; 95% CI, 1.33–2.50; I^2 = 75%) also confirmed the association between PTSD and obesity.

Conclusions: Despite some limitations, individuals suffering from PTSD seem more likely, relative to controls, to suffer from obesity. As such, individuals with this comorbidity should be targeted for intensive prevention and treatment focused on both disorders. Future research is needed to identify the role of unknown factors and mediators that might clarify the nature of this association.

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Posttraumatic stress disorder (PTSD) is a mental health condition that may affect people directly or indirectly exposed to one or more traumatic events, such as threatened death, serious injury, or sexual violence.[1] Research suggests that more than two thirds of individuals from the general population may experience a significant traumatic event at some point in their lives.[2] In the United States, PTSD estimated lifetime prevalence is 7.8%.[3] However, according to a cross-sectional survey in 6 European countries, the 12-month prevalence of PTSD is just 1.1%.[4] The effects of traumatic stress need to be considered as a major environmental challenge for both physical and psychological health.[5] Epidemiologic research found that traumatic stress exposure and PTSD are associated with several physical illnesses, including cardiovascular and gastrointestinal diseases, diabetes, fibromyalgia, and chronic fatigue syndrome.[6–8]

In recent years, there has been increasing interest in the impact of obesity[9,10] and other cardiovascular risk factors, such as metabolic syndrome,[11–15] diabetes,[9,14] and dyslipidemia,[14,16] among people suffering from mental disorders, including PTSD.[17,18] Indeed, excess body weight is the sixth most important risk factor contributing to the overall burden of disease worldwide.[19] Both overweight and obesity are associated with multiple comorbidities such as diabetes, cancer, and cardiovascular diseases,[20] and individuals with grades 2 and 3 obesity (body mass index [BMI] ≥ 35 kg/m^2) show significantly higher risk of all-cause mortality if compared with people with normal weight.[21]

PTSD may contribute to the development of obesity and other metabolic abnormalities[22] since health risk behaviors are highly frequent among people suffering from this disorder,[23] but it may influence weight gain by biological mechanisms as well. For example, enhanced negative feedback sensitivity of the glucocorticoid receptors, blunted cortisol levels, and exaggerated catecholamine responses to trauma-related stimuli have been found in individuals with PTSD (eg, Vanitallie[24]). We recently reported that, per a meta-analytic approach, individuals with PTSD have a higher risk for metabolic syndrome as compared with individuals without this disorder.[25]

However, it remains unclear whether obesity is a significant contributing factor in determining high rates of metabolic syndrome since there is a paucity of studies providing metabolic syndrome individual components rates.[26] To the best of our knowledge, there is no systematic review or meta-analysis assessing the association between PTSD and obesity, and the potential effect size of this association remains unknown. With a view to remedying these limitations, we conducted a systematic review and meta-analysis of the published literature to clarify the relevant association. We hypothesized that there are significant differences in obesity rates between people suffering from PTSD and those without this disorder.

METHODS

The present systematic review and meta-analysis was conducted according to the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) guidelines.[27] Study protocol registration was completed in the

Clinical Points

- Although posttraumatic stress disorder (PTSD) is associated with several physical illnesses, there are no systematic reviews or meta-analyses investigating its association with obesity.
- Individuals with PTSD have 1.5 times the odds of having obesity than their non-PTSD counterpart.
- Although the role of potential mediators or moderators remains unclear, clinicians should regularly assess obesity among patients with PTSD.

PROSPERO international prospective register of systematic reviews on September 23, 2013 (registration number: CRD42013005791).

Definitions

For PTSD we followed current American Psychiatric Association definition[1,28] with severe symptoms clusters including reexperiencing, avoidance, persistent negative alterations in cognition, mood, arousal and reactivity.[1]

We conventionally defined obesity as abnormal and excessive fat accumulation that may impair health. Obesity can be diagnosed when BMI, defined as individual's weight (kg) divided by the square of height (m^2), is greater than or equal to 30.[29] In our work, we also included studies using abdominal circumference to assess obesity, since the indices of abdominal obesity are considered better discriminators of cardiovascular risk factors than BMI.[30] According to the National Cholesterol Education Program—Adult Treatment Panel III[31] criteria, central obesity was defined as abdominal circumference > 102 cm (40 in) for men and > 88 cm (35 in) for women.

Search Strategy

Computerized PubMed, Embase, Scopus, Web of Science, and PILOTS, PsycINFO, and PsycARTICLES (via ProQuest) searches were performed from database inception till September 2013. There were no language restrictions. We used search phrases combining the terms *Obesity* and *Post-Traumatic Stress Disorder*. Full search strategies are detailed in eAppendix 1.

Eligibility Criteria

We included observational studies that (1) estimated obesity prevalence in a sample of people suffering from PTSD, (2) made available additional data on obesity prevalence in a comparison group without PTSD, and (3) recruited samples in which at least 95% of individuals were aged ≥ 18 years. We excluded studies without available data for crude association between PTSD and obesity. We excluded studies in which the comparison group as a whole had people with other psychiatric diagnoses. If data from the same sample were published in multiple works, we retained for meta-analysis only the study with the largest amount of information to avoid duplicate results. We included only studies published in peer-reviewed journals, excluding conference abstracts and dissertations.

Data Extraction

Two authors (A.A. and E. Paggi) made the preliminary screening based on titles and abstracts. Studies were then retrieved in full text, and final eligibility according to inclusion criteria was assessed by 2 authors independently (E. Pini and F.A.). Differences in suitability for inclusion were resolved by discussion and consensus. We built a data extraction template that included, for all eligible studies, key items based on year of publication, country of study, characteristics of recruited populations, years of data collection/recruitment, sample size, mean age, percentage of men and women, methods to assess PTSD and obesity, and main results. If raw numerical data were not reported, data for these variables were derived from percentages. When reported information was unclear, the corresponding author was contacted for clarification.

Quality Assessment

Quality assessments in meta-analyses of observational research are controversial, with no clear consensus on rating methods and their appropriate use in analyses.[27] Thus, in the present meta-analysis, we assessed quality in terms of risk of selection and misclassification biases,[32,33] with a simple objective rating system.

We considered the degree of accuracy of obesity assessment in order to classifying studies. The first group included those with objective measures (height, weight, and/or abdominal circumference directly measured). The second group included studies with less accurate methods to assess obesity; these methods included self-report as well as information on height and weight obtained from clinical records and databases.

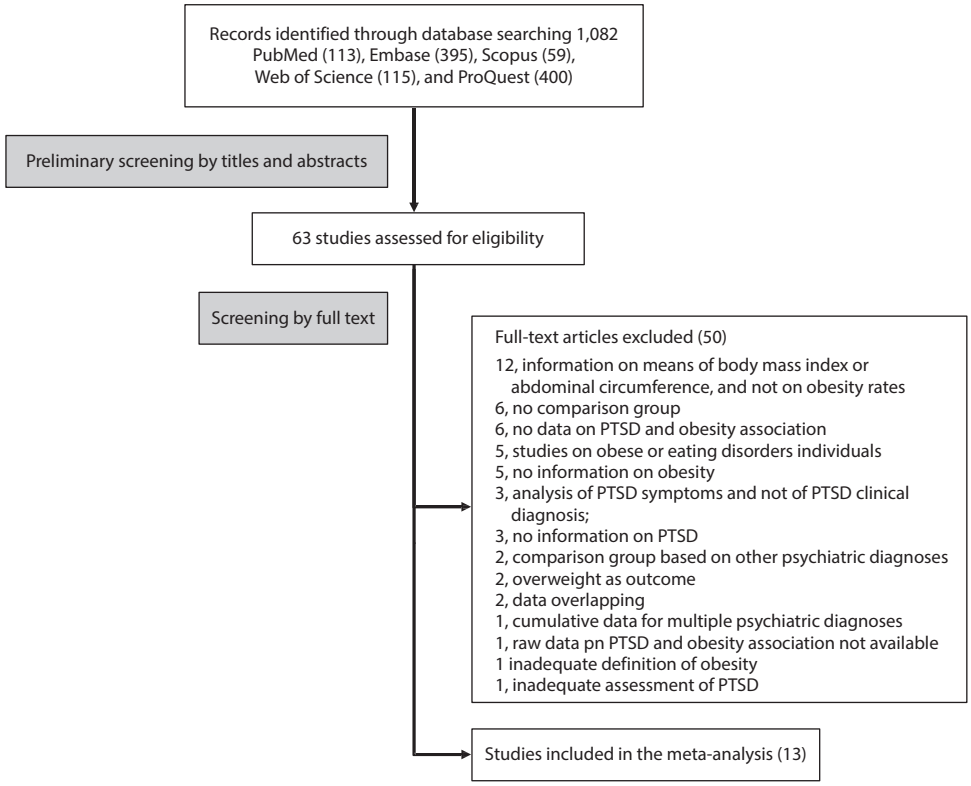
Furthermore, we evaluated studies in terms of representativeness of recruited samples (if individuals were selected from community/population-based samples and not from special groups, such as veterans or specific clinical populations) and reliability and standardization of PTSD diagnosis, as based on structured diagnostic interviews such as the Clinician-Administered PTSD Scale (CAPS),[34] the Structured Clinical Interview for *DSM-IV* (SCID),[35] the Mini-International Neuropsychiatric Interview (MINI),[36] and the Composite International Diagnostic Interview (CIDI).[37]

Consistently, we provided distinct sensitivity analyses including studies meeting highest quality criteria for each of these further domains.

Data Analysis

Analyses were performed in StatsDirect Medical Statistical Software version 2.8.0 (StatsDirect Ltd). The pooled analyses of the association between PTSD and obesity were based on odds ratios (ORs) with related 95% confidence intervals (CIs). The main analysis pooled results from all eligible studies according to our inclusion criteria. Additionally, we performed separate analyses pooling studies according to the degree of accuracy of computing BMI. Statistical significance was set at $P < .05$, and results were summarized with

Figure 1. Flow Diagram for Selection of Studies in Meta-Analysis



conventional forest plots. All pooled estimates were obtained using inverse variance models with random effects. This method weights studies more evenly and is considered more suitable for meta-analyses with substantial heterogeneity.[38] Heterogeneity among studies was estimated using the I^2 statistic, describing percentage of variation across studies owing to heterogeneity rather than chance.[39,40] However, in order to explore potential sources of heterogeneity, we also performed subgroup analyses based on main characteristics of the included studies, considering publication year (before 2010 vs in 2010 or after), geographic area, sampling source (clinical vs nonclinical settings), special populations (war veterans), gender, and sample size. Furthermore, we carried out sensitivity analyses including only studies with highest quality data in terms of accuracy of PTSD diagnosis and representativeness of recruited samples. Finally, testing for publication bias, we estimated Egger's bias coefficients with 95% CIs and 2-sided *P* values.[41]

RESULTS

Study Selection

A total of 113, 395, 59, 115, and 400 records were generated from PubMed, Embase, Scopus, Web of Science, and ProQuest (PILOTS, PsycINFO, and PsycARTICLES), respectively. The preliminary screening based on titles and abstracts identified 63 potentially relevant articles. The full text for each of these articles was retrieved for further screening. Among these, 50 were excluded because they did not meet inclusion criteria. Reasons for ineligibility are shown in the Figure 1 flow diagram. Thirteen studies were included for meta-analysis.[42–54]

Characteristics of Included Studies

Detailed characteristics of included studies are displayed in Table 1. All articles were in English, and were published between 2004[46] and 2013.[42,45,48,49,53] Most of studies (9/13; 69%) were from the United States,[43–46,48–50,53,54] and 1 each was from Bosnia and Herzegovina,[42] Croatia,[47] Germany,[51] and New Zealand.[52]. Samples sizes ranged between 120[42] and 496,722[48] cases. Eight studies were conducted among war veterans.[42–44,46–48,53,54] Five studies were entirely or predominantly (>90%) based on men,[42,43,47,53,54] 2 studies on women,[45,46] and 6 studies on mixed samples.[44,48–52] Supplementary eFigure 1 shows obesity prevalence rates among people with PTSD and comparison groups in included studies.

Quality Assessment

Five studies reported direct measures of height and weight or abdominal circumference for obesity assessment.[42,43,47,49,53] Other studies had less clear measures, calculating BMI from self-reported height and weight or from patients' clinical records.

Six studies had standardized diagnostic assessment of PTSD. Three of these used the CIDI,[50–52] and the other 3 used the CAPS[45,47,53] (in 1 case associated with the MINI[47]). Other studies did not match quality criteria on this domain

Table 1. Studies Exploring the Association Between PTSD and Obesity

Study	Country	Population (years of data collection/recruitment)	N	Age, Mean (SD), y	Men, %	Assessment of PTSD	Screening of Obesity	Cases (n/n) and Prevalence (%) of Obesity
Babić et al, 2013[42]	Bosnia and Herzegovina	Patients with war-conditioned chronic PTSD who were in outpatient psychiatric treatment at the Health Centre Mostar; the control group comprised men who needed medical attention in the dispensary of family medicine	120	PTSD: 49.6 (10.8); controls: 51.5 (15.2)	100	HTQ and clinical diagnosis of PTSD	Assessed from abdominal circumference	PTSD = 35/60 (58.3); controls = 23/60 (38.3)
Boscarino, 2008[43]	United States	Random sample of male veterans who served in the US Army during the Vietnam War identified through the National Personnel Records Center, St Louis, Missouri (1985–1986)	4,328	39 (NA); age range: 32–49 y	100	*DSM-III* PTSD scale	Assessed from height and weight	PTSD = 55/311 (17.7); controls = 650/4,017 (16.2)
Coughlin et al, 2011[44]	United States	Individuals from a follow-up survey to the 1995 National Health Survey of Gulf War Era Veterans and Their Families (2003–2005)	9,970	46.3 (NA)	79.2	PCL ≥ 50	Assessed from self-reported height and weight	PTSD = 377/1,046 (36.0); controls = 2,442/8,585 (28.4)
Dedert et al, 2013[45]	United States	Women recruited via advertising for a study on trauma and health posted at 2 local hospitals and a more general flyer to recruit participants for a non-PTSD comparison group (2001–2005)	134	40.4 (12.9)	0	CAPS	Assessed from self-reported height and measured weight	PTSD = 40/63 (63.5); controls = 27/71 (38.0)
Dobie et al, 2004[46]	United States	Female veterans who received care between 1996 and 1998 at VA Puget Sound were mailed a Women's Health Survey as part of a larger cross-sectional survey of women seen for outpatient care (1998)	1,206	46 (15)	0	PCL ≥ 50	Assessed from self-reported height and weight	PTSD = 125/266 (47.0); controls = 332/940 (35.3)
Kozaric-Kovacic et al, 2009[47]	Croatia	Combat-exposed veterans recruited as consecutive inpatients or outpatients from the Department of Psychiatry and the Referral Centre for Stress Related Disorders of the University Hospital Dubrava (2005–2008)	478	PTSD: 41.4 (6.1); controls: 40.8 (6.1)	100	CAPS and MINI	Assessed from measured height and weight	PTSD = 69/269 (25.7); controls = 55/209 (26.3)
Maguen et al, 2013[48]	United States	Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn veterans who served in Afghanistan and Iraq and who had used the VA health care system for a clinical visit from October 2001 to December 2011	496,722	28.4 (4.7)	88	*ICD-9* diagnostic codes for PTSD associated with VA clinical visits	Assessed from patient's recorded height and weight measurements	PTSD = 63,933/186,364 (34.3); controls = 98,979/310,358 (31.9)
Mitchell et al, 2013[49]	United States	African American adults from a subsample of the Detroit Neighborhood Health Study (2008–2009)	453	56.7 (NA)	37.3	PCL	Assessed from measured height and weight	PTSD = 63/107 (58.9)[a]; controls = 166/346 (48.0)[a]
Pagoto et al, 2012[50]	United States	Individuals recruited from Collaborative Psychiatric Epidemiology Surveys, which comprises the National Comorbidity Survey Replication, the National Survey of American Life, and the National Latino and Asian American Study of Mental Health (2001–2003)	20,013	44.9 (NA)	47.4	CIDI	Assessed from self-reported height and weight	Past year PTSD = NA (32.6)[b]; lifetime PTSD = NA (25.5); controls = NA (24.1)
Perkonigg et al, 2009[51]	Germany	A representative community sample from the Wave 4 of the Early Developmental Stages of Psychopathology Study (2004–2005)	1,943	NA; age range: 21–34 y	53.5	CIDI	Assessed from measured (baseline) and self-reported (follow-up) height and weight	PTSD = 7/61 (11.5); controls = 74/1,882 (3.9)

(continued)

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Table 1 (continued). Studies Exploring the Association Between PTSD and Obesity

Study	Country	Population (years of data collection/recruitment)	N	Age, Mean (SD), y	Men, %	Assessment of PTSD	Screening of Obesity	Cases (n/n) and Prevalence (%) of Obesity
Scott et al, 2008[52]	New Zealand	Subjects from Te Rau Hinengaro: the New Zealand Mental Health Survey, a nationally representative household survey (2003–2004)	12,992	NA; 69.2% in age range between 25 and 64 y	48.0	CIDI	Assessed from self-reported height and weight	PTSD = 304/828 (32.6)[a]; controls = 1,819/6,484 (19.4)[a]
Turner et al, 2013[53]	United States	Participants were recruited from outpatient clinics affiliated with 2 Department of Veterans Affairs Medical Centers (the San Francisco VA Medical Center and the VA Palo Alto Health Care System, California) (2008–2010)	663	PTSD: 58.2 (10.3); controls: 58.0 (11.6)	94.3	CAPS	Assessed from measured height and weight	PTSD = 98/230 (42.6) controls = 135/433 (31.2)
Vieweg et al, 2007[54]	United States	Patients randomly selected from the Department of Veterans Affairs Central Office Database (2004)	46,778	63.8 (13.5)	100	Having a *DSM-IV* PTSD diagnosis with at least 3 outpatient visits or 2 hospital admissions over the course of a year	Assessed from database information on height and weight	PTSD = 735/1819 (40.4); controls = 13,710/44,959 (30.5)

[a]Data provided by the authors.
[b]Unadjusted OR reported.
Abbreviations: CAPS = Clinician Administered PTSD Scale, CIDI = Composite International Diagnostic Interview, HTQ = Harvard Trauma Questionnaire, MINI = Mini International Neuropsychiatric Interview, NA = not available, PCL = PTSD checklist, PTSD = posttraumatic stress disorder, SD = standard deviation, VA = Veterans Administration.

since they used clinical records or checklist scales detecting clinical symptoms to gather PTSD diagnosis.

Finally, 3 studies used fully representative epidemiologic samples from community surveys.[50–52] Eight studies were based on special populations of war veterans: 3 of these derived data from health records,[43,48,54] 2 derived data from previously conducted surveys,[44,46] and 3 recruited from clinical settings.[42,47,53] Alternative recruitment procedures included advertisement at local hospitals[45] and a longitudinal cohort of predominantly African American men and women in Detroit.[49]

Obesity Among People Suffering From PTSD

Thirteen studies (N = 589,781) reported unadjusted results for the effect of PTSD on obesity. The overall pooled OR was 1.55 (95% CI, 1.32–1.82; $P < .001$; see Figure 2). Heterogeneity was high ($I^2 = 90\%$), and Egger's linear regression test showed high risk of publication bias (coeff = 2.63 [1.22 to 4.04]; $P = .002$). Thus, we also performed subgroup analyses based on degree of accuracy for obesity diagnosis (Figure 2). Studies using direct measures of height and weight to assess BMI showed a pooled OR of 1.35 (95% CI, 1.05–1.74; $P = .02$), with moderate heterogeneity ($I^2 = 47\%$), whereas a pooled OR of 1.66 (95% CI, 1.35–2.04), with high heterogeneity ($I^2 > 90\%$), was found from studies with less accurate methods for obesity assessment.

Results of other subgroup analyses based on different characteristics of included studies are detailed in Table 2.

Furthermore, as regards sensitivity analyses, we found, including only studies assessing PTSD using standardized interviews, an OR for obesity of 1.82 (1.33–2.50; $P < .001$; $I^2 = 75\%$) among PTSD individuals, while an even stronger association between PTSD and obesity was observed when only high-quality studies in terms of representativeness of populations were included (OR = 2.14; 95% CI, 1.37–3.33; $P < .001$; $I^2 = 79\%$) (see Supplementary eTable 1).

DISCUSSION

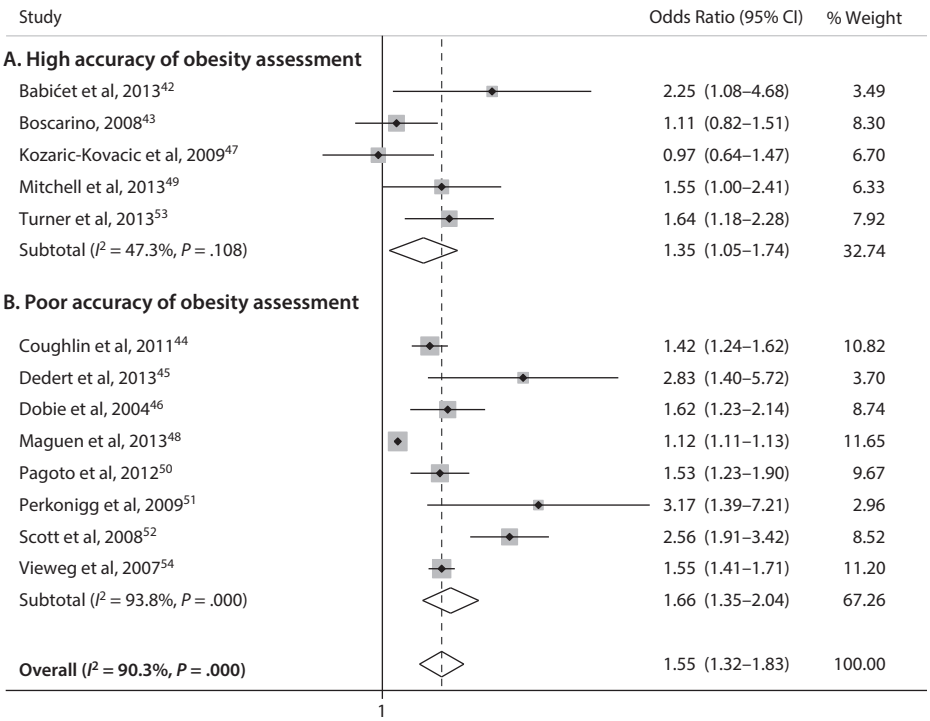
Summary of Findings

To our knowledge, this is the first comprehensive meta-analysis of obesity in subjects with PTSD. We identified 13 observational studies that included 589,781 participants. Our hypothesis that people suffering from PTSD would have significantly higher risk of obesity is confirmed. PTSD individuals had 1.5 times the odds of having obesity compared with their non-PTSD counterparts. The findings of this meta-analysis are consistent with the previous scientific work that had shown elevated rates of obesity among individuals suffering from mental disorders.[25,55,56] Importantly, our findings do not seem substantially modified by the methods used to assess obesity and PTSD or by the nature of populations considered. An association was found regardless of the accuracy of measures and in both veteran and non-veteran PTSD samples. Furthermore, other subgroup analyses based on period of publication, geographic area, sampling source, gender, and sample size, as well as sensitivity analyses based on quality rating, all consistently confirm the relationship.

Clinical Implications

This meta-analysis provides important information not only for mental health professionals working with people with PTSD, but also

Figure 2. Effect of PTSD on Obesity by Study and Pooled Analysis of Studies With High Versus Poor Accuracy of Obesity Assessment



for physicians and allied health professionals dealing with obesity issues, suggesting the need to regularly assess relevant clinical parameters. The importance of this topic is documented by the growing scientific evidence that consistently reports the need for raising awareness of physical health problems, especially weight gain, in people suffering from mental illnesses.[9,57,58] Obesity may explain at least partially the high rates of metabolic syndrome,[25] cardiovascular diseases,[18] and early mortality[59] among these individuals. The long-term routine monitoring of individuals with PTSD should include an extensive evaluation of medical history, lifestyle habits, clinical conditions, metabolic parameters such as BMI or waist circumference, and blood pressure values as well as regular blood examination of fasting glucose and lipids.[25] Of course, there is the need to consider the costs and benefits associated with a comprehensive screening for obesity in PTSD versus non-PTSD populations. Although our findings show that numbers needed to be screened to detect additional cases of obesity among PTSD subjects are not small, the clinical impact could be still beneficial considering the relative ease of obtaining BMI measures.[60]

Obviously other, different, factors may explain or mediate the association between PTSD and obesity. First, obesity-related behavioral risk factors may be highly prevalent in people with PTSD, who may eat more high-fat/high-calorie diets[61] and have low levels of physical exercise.[62] Second, the association between PTSD and obesity may be mediated by stress-induced metabolic alterations. Stressful life events are associated with obesity, but also with insulin resistance, hypertriglyceridemia, and poor general metabolic health.[63] These associations may be mediated by alterations in the hypothalamic-pituitary-adrenal (HPA) axis and changes in glucocorticoid system.[64] Therefore, obesity might be a consequence of neuroendocrinal adaptations to chronic stress in people with PTSD.[22] However, prospective studies would be needed to determine a causal relationship. Thus, preliminary findings on the role of the HPA axis need

Table 2. Subgroup Analyses for Characteristics of Studies

Study Characteristics	No. of Samples	Odds Ratio (95% CI)	*Z*	*P*	I^2
Period of publication					
2010–2013	7	1.50 (1.23–1.83)	3.99	<.001	84%
Before 2010	6	1.58 (1.22–2.04)	3.51	<.001	80%
Geographical area					
United States	9	1.45 (1.23–1.71)	4.45	<.001	90%
Outside of United States	4	1.97 (1.10–3.54)	2.28	.02	81%
Sampling source					
Clinical setting	6	1.47 (1.12–1.93)	2.80	.005	78%
Nonclinical setting	7	1.60 (1.36–1.87)	5.67	<.001	72%
Special population					
Veterans	8	1.36 (1.15–1.62)	3.56	<.001	90%
Non-veterans	5	2.05 (1.50–2.80)	4.52	<.001	65%
Gender					
Men[a]	5	1.39 (1.12–1.72)	2.97	.003	60%
Women	2	1.94 (1.16–3.24)	2.54	.01	52%
Men and women	6	1.62 (1.25–2.09)	3.68	<.001	92%
Sample size					
<1,000	5	1.60 (1.16–2.22)	2.85	.004	55%
1,000–10,000	5	1.69 (1.26–2.27)	3.53	<.001	81%
>10,000	3	1.37 (1.05–1.79)	2.33	.02	96%

[a]Samples totally or mainly (>90%) of men.

to be considered with care as it is premature to draw any definitive conclusions. Third, pharmacologic treatments, including antipsychotics[65] and antidepressant agents,[66] may play a major role in explaining this association. An analysis on the Veterans Affairs health care system showed that PTSD was the most common mental illness among patients prescribed antipsychotics for off-label indications,[67] and second-generation (or atypical) antipsychotics are associated with a wide range of metabolic abnormalities, including weight gain, hyperglycemia, and dyslipidemia.[68] Further alternative explanations could involve comorbidity of depressive disorders among people with PTSD[69] since these are the mental health disorders most commonly diagnosed with PTSD,[70–72] and findings from a relatively recent meta-analysis highlighted that depression is a predictive factor for obesity.[73] Finally, PTSD may be associated with emotional eating, ie, the tendency to eat or overeat in response to a range of negative emotions.[74] A recent study on a sample of medically healthy and medication-free adults showed that individuals suffering from PTSD had greater emotional eating than controls, and emotional eating scores increased with higher severity of PTSD symptoms.[75]

Strengths and Limitations

To our knowledge, this is the first meta-analysis that systematically synthesizes a large amount of data from international studies comparing obesity rates between adults with and without PTSD. However, longitudinal and prospective analyses studying this relationship are needed to investigate the influence of pharmacologic treatment, lifestyle habits, or other factors on the risk of obesity among people with PTSD. Since observational studies are often prone to several methodologic limitations, we paid attention to quality evaluation of included studies. We checked if the included studies were affected by potential sources of selection or misclassification biases. We evaluated quality in terms of representativeness of recruited samples, but also of BMI and PTSD assessment, carrying out sensitivity analyses based on best-quality data. These confirmed the association between PTSD and obesity. However, we found a great level of heterogeneity. This may be due to the high degree of variability across the pooled studies in terms of recruitment strategies, sampled populations, inclusion criteria, and methods to assess obesity and PTSD. We explored the potential sources of heterogeneity by performing subgroup analyses, which confirmed that the association between PTSD and obesity cannot be explained by any single specific characteristic of the studies considered.

The main limitation of this meta-analysis is the high risk of publication bias that may have affected our findings at least partially. There are at least 3 classical potential explanations that may elucidate this issue. First, our search strategies may not have been able to entirely identify all studies published on the relationship between PTSD and obesity. However, this possibility seems unlikely since we searched across multiple databases simultaneously, warranting an extensive coverage of published literature on the topic.[76] Secondly, risk of publication bias might be due to smaller studies, which are more likely to be published if they have large, significant effect sizes.[77] Nonetheless, based on our sample size subgroup analyses, studies with high standard errors (ie, smaller studies) did not show an association stronger than that found from large studies. More importantly, observational studies are often biased by the selective report of more attractive results.[78] It should be considered that there might be an amount of negative/uncertain results on the association between obesity and PTSD that remained unpublished or underreported. Our findings therefore need to be interpreted with caution, taking into account all potential sources of biases affecting the actual pooled effect size of the association between PTSD and obesity. In addition, besides that of subgroups analyses, we could not explore the role of candidate moderators and mediators because of lack of relevant data from included studies. Finally, it should be highlighted that our analyses obviously could not include future studies using recent *DSM-5* diagnostic criteria for PTSD. However, no significant related variation may be hypothesized, due to the high consistency between *DSM-IV* and *DSM-5* diagnostic criteria (eg, Carmassi et al[79]).

CONCLUSIONS

Despite some limitations, our meta-analysis highlights that PTSD is associated with obesity. Individuals suffering from PTSD should be considered a vulnerable population for metabolic disorders in general and particularly for obesity. The potential role of unknown moderators and mediators that might clarify the nature of this association deserves additional research, but the need for obesity screening and treatment in people with PTSD is already clear. Primary care for individuals at high risk for trauma exposure should probably focus on early monitoring and screening of adverse physical outcomes.[17] Unfortunately, there are not well defined evidence-based protocols for prevention of physical diseases among people with PTSD. Future research should assess longitudinally the impact of screening, prevention, and treatment measures for individuals with PTSD on health status and life expectancy,[25] but also whether PTSD symptom reduction over the course of treatment may be associated with variations in physical health outcomes.[80] In the meantime, the need for routine assessment of obesity in PTSD programs is clear enough to be incorporated into training for mental health professionals working with people with PTSD.

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Supplementary material follows this article.

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Supplementary Material

Article Title: Posttraumatic Stress Disorder and Risk of Obesity: Systematic Review and Meta-Analysis

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List of Supplementary Material for the article

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3. **eTable 1** Sensitivity analyses by quality domains

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This Supplementary Material has been provided by the author(s) as an enhancement to the published article. It has been approved by peer review; however, it has undergone neither editing nor formatting by in-house editorial staff. The material is presented in the manner supplied by the author.

eAppendix 1. Search strategies

- PUBMED
  ("Obesity"[Mesh] or obes[title/abstract] or BMI [title/abstract] or "Metabolic Syndrome X"[Mesh]) AND ("Stress Disorders, Post-Traumatic"[Mesh] or PTSD [title/abstract])*

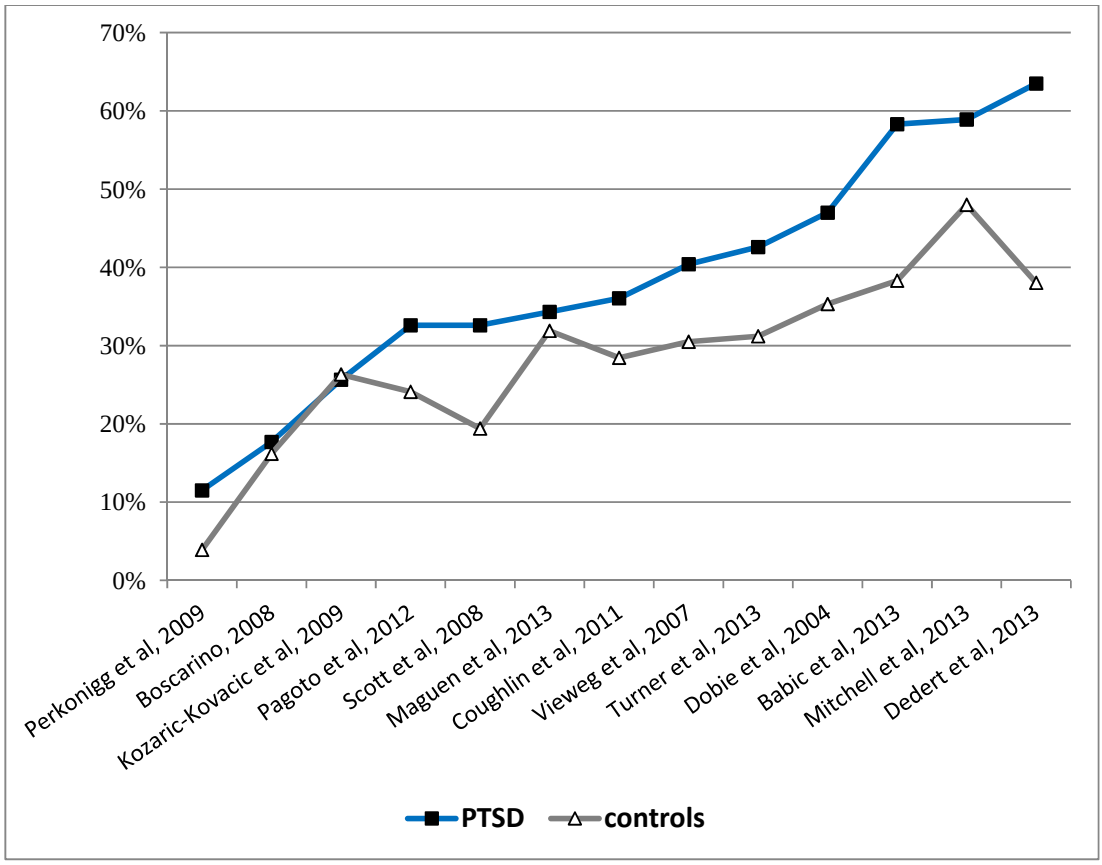
- EMBASE
  ('obesity'/exp or 'abdominal obesity'/exp or obes:ab,ti OR bmi:ab,ti) AND ('posttraumatic stress disorder'/exp or ptsd:ab,ti)*

- PILOTS, Psycinfo and Psycarticles (via ProQuest)
  (obes or BMI or metabolic syndrome) AND PTSD*

- SCOPUS
  (TITLE-ABS-KEY(obes or metabolic syndrome or bmi) AND TITLE-ABS-KEY(ptsd))*

- WEB OF SCIENCE
  Topic=(obes or metabolic syndrome or BMI) AND Topic=(PTSD)*

Supplementary eFigure 1. Obesity prevalence rates in PTSD and controls



Supplementary eTable 1. Sensitivity analyses by quality domains

Study	Direct measure of BMI or abdominal circumference	Standardized diagnosis of PTSD	Sample Representativeness
Babic et al, 2013	+	-	-
Boscarino, 2008	+	-	-
Coughlin et al, 2011	-	-	-
Dedert et al, 2013	-	+	-
Dobie et al, 2004	-	-	-
Kozaric-Kovacic et al, 2009	+	+	-
Maguen et al, 2013	-	-	-
Mitchell et al, 2013	+	-	-
Pagoto et al, 2012	-	+	+
Perkonigg et al, 2009	-	+	+
Scott et al, 2008	-	+	+
Turner et al, 2013	+	+	-
Vieweg et al, 2007	-	-	-
OR [95%CI]	**1.35 [1.05-1.74]**	**1.82 [1.33-2.50]**	**2.14 [1.37-3.34]**
Z	**2.36**	**3.74**	**3.34**
P	**0.018**	**<0.001**	**<0.001**
I^2	**47%**	**75%**	**79%**