Association Between Symptoms of Posttraumatic Stress Disorder and Signs of Temporomandibular Disorders in the General Population

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Aims: To estimate the association between signs of temporomandibular disorders (TMD) and symptoms of posttraumatic stress disorder (PTSD) in a representative sample from the general population of northeastern Germany. **Methods:** Signs of TMD were assessed with a clinical functional analysis that included palpation of the temporomandibular joints (TMJs) and masticatory muscles. PTSD was assessed with the PTSD module of the Structured Clinical Interview for the Diagnostic and Statistical Manual of Mental Disorders, ed 4. The change-in-estimate method for binary logistic regression models was used to determine the final model and control for confounders. **Results:** After the exclusion of subjects without prior traumatic events, the sample for joint pain consisted of 1,673 participants with a median age of 58.9 years (interquartile range 24.8), and the sample for muscle pain consisted of 1,689 participants with a median age of 59.1 years (interquartile range 24.8). Of these samples, 84 participants had pain on palpation of the TMJ, and 42 participants had pain on palpation of the masticatory muscles. Subjects having clinical PTSD (n = 62) had a 2.56-fold increase in joint pain (odds ratio [OR] = 2.56; 95% confidence interval [CI]: 1.14 to 5.71, $P = .022$) and a 3.86-fold increase (OR = 3.86; 95% CI: 1.51 to 9.85, $P = .005$) in muscle pain compared to subjects having no clinical PTSD. **Conclusion:** These results should encourage general practitioners and dentists to acknowledge the role of PTSD and traumatic events in the diagnosis and therapy of TMD, especially in a period of international migration and military foreign assignments. *J Oral Facial Pain Headache 2019;33:67–76. doi: 10.11607/ofph.1905*

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Chronic pain is a large and rapidly growing public health problem.[1,2] Lower back, joint, head, and facial pain are the most frequent manifestations of chronic pain.[3–5] Temporomandibular disorders (TMD) may also manifest as chronic pain[5] and are widely used as a chronic pain model.[6] The term TMD is a collective term encompassing a number of clinical problems that involve the masticatory muscles, the temporomandibular joint (TMJ) and associated structures, or both.[7,8] Occurrences of one or more clinical signs of TMD in epidemiologic studies have been described as between 33% and 86%,[9,10] while the prevalence of one or more clinical signs of TMD in a general population study in northeastern Germany was 49.9%.[11]

Risk factors for TMD pain include conditions such as depression and anxiety,[12] psychological distress, and perceived life stress.[13] An extreme stressor or a traumatic event can result in posttraumatic stress disorder (PTSD).[14] PTSD is characterized by distressing and/or impairing symptoms that occur after experiencing, witnessing, or being confronted with a traumatic event that includes an actual or perceived threat to the self or others. It involves repeated and intrusive memories related to the trauma, avoidance of trauma-related stimuli, and hyperarousal.[15] PTSD is widespread[16]: its prevalence is 10% in rescue workers[17] and 3% to 6% in United Kingdom war veterans returning from the Iraq War,[18] while its prevalence in the general population varies from 1.3% to 4.0%.[3,16,17] A mutual maintenance model for chronic pain and PTSD has been proposed.[1] Cognitive, affective, and behavioral components

of chronic pain may exacerbate and maintain PTSD, while the physiologic, affective, and avoidance components of PTSD may exacerbate and maintain problems associated with chronic pain.[1] PTSD has been associated with chronic daily headaches, chronic migraine headaches,[19] and chronic orofacial pain.[20]

PTSD has also been associated with TMD pain in a community-based sample of American twin pairs: Female twins with PTSD symptoms had a 3-fold increased risk for symptoms of TMD. TMD symptoms in that study were defined using a screening questionnaire for common chronic pain symptoms without a clinical examination.[21] A standardized clinical functional analysis of TMD that used the Research Diagnostic Criteria for TMD (RDC/TMD)[22] and a routine psychometric test were performed in a study of chronic pain patients who sought treatment at the Orofacial Pain Center of the University of Kentucky. This study found that differing PTSD symptom clusters predicted different components of pain, indicating that researchers should investigate the predictive power of these clusters.[23] Selection bias due to treatment-seeking behavior may have occurred in clinical samples of PTSD recruited in orofacial pain centers, which is typically considered a threat to validity.[24] In addition, PTSD in orofacial pain centers may be accompanied by a high degree of comorbid psychopathology, as has been previously demonstrated in Croatian War veterans,[25,26] limiting the generalizability of study findings. In population-based studies, a clinical functional analysis with palpation has not been performed.[21]

To estimate the clinical impact of the association between PTSD and signs of TMD in primary care and dental practice settings, this association needs to be quantified in a general population study.[14,20] In a period of international migration and military foreign assignments, prior knowledge about the effect of PTSD on TMD as a model for chronic pain in a general population may be helpful for clinicians. Therefore, the aim of this study was to estimate the association between signs of TMD and symptoms of PTSD in a representative sample from the general population of northeastern Germany.

Materials and Methods

Participants

The Study of Health in Pomerania (SHIP) is a longitudinal, population-based study in West Pomerania, northeastern Germany. At baseline, a total of 212,157 inhabitants lived in the study region. Population registries were used to select German citizens residing in the study area aged between 20 and 79 years, and 7,008 persons were invited at baseline.[27] The net sample (without migrated or deceased persons) was comprised of 6,265 eligible subjects, with 4,308 (68.8%) agreeing to participate. The local ethics committee approved the study. All participants gave written informed consent. The study protocol and examination tools were set up from 1995 onwards.[28] Data collection was conducted from October 1997 to May 2001. The follow-up examination, termed SHIP-1, was conducted from October 2002 to September 2006 and included 3,300 participants. The subset of subjects with at least one traumatic event from SHIP-1 (Fig 1) was used for inference.[29–31]

Outcome and Exposure Measures

The outcome variable—signs of TMD—was assessed using data from the oral clinical examination. The oral clinical examination was performed by 8 trained and certified dentists, and inter-rater reliability for TMD signs was calibrated over the course of five sessions in a total of 22 volunteers.[32] Training of the dentists and consensus discussions were performed before the study began and biannually during the data collection period.[28] TMD examinations were performed following the guidelines for the diagnosis of TMD defined by the American Academy of Orofacial Pain.[33] To reach a higher degree of specificity, the outcome variable was divided into two end points: TMJ pain (arthralgia) and masticatory muscle pain. TMJ pain was defined by employing two palpation techniques: palpation of the lateral condyles and a static pain test (compressing the TMJ in a dorsocranial direction[33,34]).

For the static examination, the participant was instructed to hold the mandible while the examiner gradually increased the pressure.[34] The condyles were compressed in the dorsocranial direction with the participant's mandible in the relaxed position.[11] Lateral condyle palpation was performed while the participant's mouth was slightly open. The condyles were palpated with a pressure of approximately 2 kg/cm^2 on the left and right sides simultaneously, and the subjects were asked to describe their perception as either indolent/painless, uncomfortable, or painful. These palpation techniques resulted in four measures for the TMJ. Pain in the masseter and temporalis muscles was assessed bilaterally, yielding a total of four measures. These masticatory muscles were palpated extraorally with a pressure of approximately 1 kg/cm^2. The subjects' resulting perceptions of pain, using the three descriptors specified above, were documented. To differentiate pain from discomfort, each outcome (joint pain and muscle pain) was defined as being present if there was at least one site of pain on palpation. The category uncomfortable was not excluded, but termed as indolent/painless. Similarly, the TMD cases were only defined by pain. In ancillary analyses, however, subjects having pain or discomfort were defined as cases.

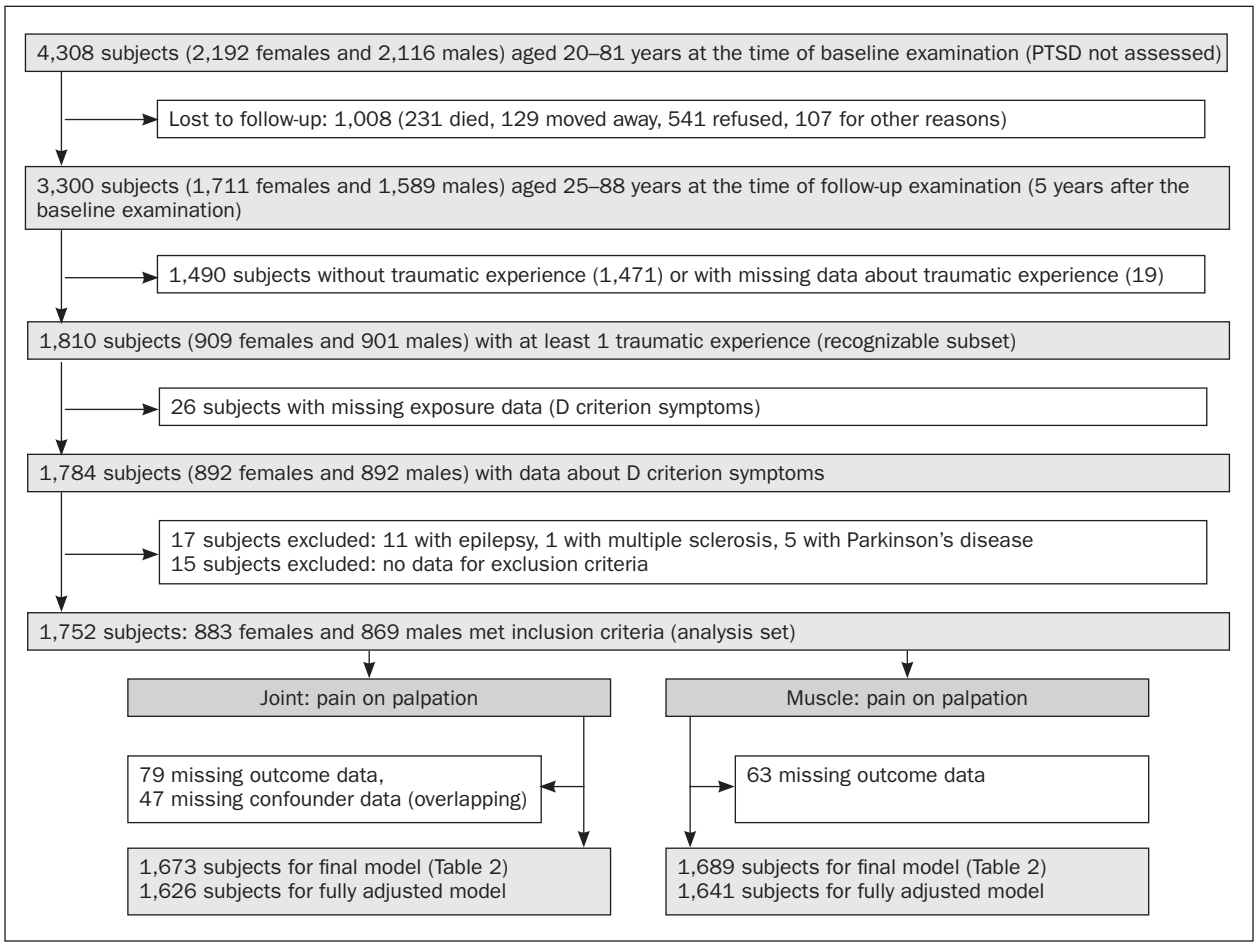

Fig 1 Description of the study population.

Interview and Psychometric Assessments

The health-related interview of SHIP-1 involved the PTSD module of the Structured Clinical Interview (SCID) for the Diagnostic and Statistical Manual of Mental Disorders, ed 4 (DSM-IV),[35] the Mini-Mental State Examination,[36] and the Composite International Diagnostic-Screener (CID-S).[37] The PTSD module of the SCID[35] was used to assess trauma exposure and PTSD. The following traumatic events were assessed: combat or war zone experience; physical assault; rape; childhood sexual abuse; natural disaster; serious or nearly fatal accident; imprisonment and/or torture; life-threatening illness; sudden and unexpected death of a loved one; and witnessing or learning about trauma experienced by others. If a participant answered "no" to all of the trauma questions, the module was terminated. If exposure to trauma was reported, the interview was continued, and the DSM-IV items for PTSD symptoms were assessed, including criterion A2 (experiencing high distress during/after the event), criterion B (five symptoms of re-experiencing the event), criterion C (seven avoidance symptoms), and criterion D (five hyperarousal symptoms). To determine the diagnosis of PTSD, at least one symptom of re-experiencing, three symptoms of avoidance, and two symptoms of hyperarousal were required. If the participant did not pass the first diagnostic threshold required (eg, at least one re-experiencing symptom), the interview was terminated.[3]

A version of the Oral Health Impact Profile (OHIP) later described as the German short form OHIP-G14a was used, with one exception: in SHIP, item 20 on the OHIP-G14a was replaced by item 36.[38]

Symptoms of depression and anxiety disorders that occurred during the 12 months prior to the examination were assessed in a face-to-face interview using the CID-S.[37] The CID-S is a 12-item screening instrument established for representing key symptoms of mental disorders.[37] Eight questions on the CID-S were designed to assess the lifetime occurrence of somatoform, anxiety, and depressive disorders. The following screening questions for depressive disorders were used: ''Have you ever suffered from feelings of sadness or depressed mood for a period of at least 2 weeks?'' and ''Have you ever

Table 1 Characteristics of Study Participants with at Least One Traumatic Experience from SHIP-1 at Examination in 2002–2006

	Joint: Pain on palpation (n = 1,673)		Muscle: Pain on palpation (n = 1,689)	
	Indolent/uncomfortable	Painful	Indolent/ uncomfortable	Painful
No. of participants	1,589	84	1,647	42
Subjects with PTSD criteria symptoms present				
D criterion symptoms				
0 (reference)	1,516 (95.4)	72 (85.7)	1,568 (95.2)	35 (83.3)
1	19 (1.2)	4 (4.8)†	22 (1.3)	1 (2.4)
2	22 (1.4)	2 (2.4)	23 (1.4)	1 (2.4)
3	15 (0.9)	1 (1.2)	13 (0.8)	3 (7.1)‡
4	13 (0.8)	2 (2.4)	15 (0.9)	1 (2.4)
5	4 (0.3)	3 (3.6)‡	6 (0.4)	1 (2.4)
C criterion symptoms	582 (36.6)	42 (50.0)*	609 (37.0)	23 (54.8)*
B criterion symptoms	1,032 (64.9)	67 (79.8)***	1,071 (65.0)	36 (85.7)**
≥ 2 traumatic events	575 (36.2)	34 (40.5)	597 (36.2)	21 (50.0)
Age (y), median ± IQR	59.2 ± 24.7	51.1 ± 20.6*	59.1 ± 25.0	57.0 ± 22.1
Female	785 (49.4)	58 (69.0)***	817 (49.6)	31 (73.8)**
OHIP-G14a sum score ≥ 1[a]	350 (22.0)	22 (26.2)	361 (21.9)	17 (40.5)**
OHIP-G14a sum score ≥ 4[b]	125 (7.9)	8 (9.5)	125 (7.6)	10 (23.8)**
Fair or bad general health[a]	302 (19.0)	18 (21.4)	315 (19.1)	13 (31.0)
Depressive symptoms in the last year[a]	352 (22.2)	29 (34.5)*	373 (22.7)	14 (33.3)
Depressive lifetime symptoms 5 y ago	503 (32.0)	48 (57.8)***	537 (32.9)	21 (50.0)*
Anxiety symptoms in the last year	389 (24.5)	31 (36.9)*	409 (24.8)	16 (38.1)
Anxiety lifetime symptoms 5 y ago[a]	802 (50.8)	54 (65.9)**	832 (50.9)	33 (80.5)***
School education				
8 y (reference)	710 (44.7)	28 (33.3)	733 (44.6)	15 (35.7)
10 y	644 (40.6)	45 (53.6)	673 (40.9)	22 (52.4)
12 y	233 (14.7)	11 (13.1)	239 (14.5)	5 (11.9)
Household income per mo (€), median ± IQR	1,550 ± 950	1,550 ± 950	1,550 ± 950	1,184 ± 655
Household income, quintiles				
1st quintile: ≤ 1,096 €	310 (20.1)	20 (24.7)	322 (20.2)	13 (31.7)
2nd quintile: > 1,096–1,450 €	313 (20.3)	14 (17.3)	323 (20.3)	8 (19.5)
3rd quintile: > 1,450–1,550 €	382 (24.8)	19 (23.5)	394 (24.7)	10 (24.4)
4th quintile: > 1,550–2,050 €	290 (18.8)	13 (16.0)	302 (18.9)	4 (9.8)
5th quintile: > 2,050 €	244 (15.9)	15 (18.5)	254 (15.9)	6 (14.6)
Marital status				
Single	204 (12.8)	5 (6.0)	204 (12.4)	8 (19.0)
Married (reference)	1,038 (65.3)	56 (66.7)	1,079 (65.5)	24 (57.1)
Divorced/married but separated	145 (9.1)	15 (17.9)*	155 (9.4)	8 (19.0)*
Widowed	202 (12.7)	8 (9.5)	209 (12.7)	2 (4.8)
Arthritis[a]	232 (14.7)	15 (18.1)	238 (14.5)	13 (31.0)**
Degenerative disc disease	812 (51.1)	44 (52.4)	840 (51.0)	28 (66.7)*
Osteoporosis[a]	110 (7.1)	3 (3.7)	109 (6.8)	8 (19.5)**
Migraine[a]	40 (2.5)	7 (8.3)†	41 (2.5)	6 (14.3)**
Cancer[a]	130 (8.2)	7 (8.3)	137 (8.3)	3 (7.1)
Alcohol consumption				
0 g/d	288 (18.1)	8 (9.5)	291 (17.7)	9 (21.4)
> 0–10 g/d	876 (55.5)	58 (69.0)	918 (55.7)	25 (59.5)
11–20 g/d	210 (13.2)	10 (11.9)	216 (13.1)	5 (11.9)
21–30 g/d	89 (5.6)	4 (4.8)	92 (5.6)	2 (4.8)
> 30 g/d	126 (7.9)	4 (4.8)	130 (7.9)	1 (2.4)
Edentulism (related to 32 teeth)[a]	235 (14.8)	6 (7.1)*	244 (14.8)	2 (4.8)*
Teeth in dentate subjects, median ± IQR[a]	23 ± 13	23 ± 11	23 ± 13	22.5 ± 13.5
Eichner classification, including partial dentures				
A (reference)	656 (41.3)	39 (46.4)	677 (41.1)	20 (47.6)
B1	163 (10.3)	10 (11.9)	171 (10.4)	4 (9.5)
B2	120 (7.6)	7 (8.3)	127 (7.7)	1 (2.4)
B3	90 (5.7)	6 (7.1)	96 (5.8)	2 (4.8)
B4	119 (7.5)	8 (9.5)	122 (7.4)	5 (11.9)
C	440 (27.7)	14 (16.7)	453 (27.5)	10 (23.8)

Values are number (percentage) unless otherwise specified.

[a]n < 1,673 for joint pain or n < 1,689 for muscle pain because of missing values.

[b]The median of the OHIP-14 sum score was 0 in each group; therefore, the proportions ≥ 1 and ≥ 4 are given.

[c]*P* value from median unbiased estimates.

IQR = interquartile range; OHIP-G14a = German Oral Health Impact Profile; ATC = Anatomical Therapeutic Chemical.

*$P < .05$; **$P < .01$; ***$P < .001$.

Table 1 cont. Characteristics of Study Participants with at Least One Traumatic Experience from SHIP-1 at Examination in 2002–2006

	Joint: Pain on palpation (n = 1,673)		Muscle: Pain on palpation (n = 1,689)	
	Indolent/uncomfortable	Painful	Indolent/ uncomfortable	Painful
Suboccipital muscles (right or left side)				
Indolent (reference)	1,550 (97.6)	78 (94.0)	1,610 (97.8)	34 (81.0)
Uncomfortable	18 (1.1)	2 (2.4)	19 (1.2)	2 (4.8)
Painful	20 (1.3)	3 (3.6)	17 (1.0)	6 (14.3)***
Sternocleidomastoid muscles (right or left side)				
Indolent (reference)	1,586 (99.9)	82 (97.6)	1,644 (99.9)	40 (95.2)
Uncomfortable	2 (0.1)	0 (0)	2 (0.1)	0 (0)
Painful	0 (0)	2 (2.4)**[c]	0 (0)	2 (4.8)**[c]
Headache[a]	54 (3.4)	5 (6.0)	57 (3.5)	2 (4.8)
Medication (ATC code)				
M01A, NSAID	182 (11.5)	10 (11.9)	183 (11.1)	10 (23.8)*
M01B, NSAID in combination	0 (0)	0 (0)	0 (0)	0 (0)
N02A, opioids	32 (2.0)	4 (4.8)	36 (2.2)	2 (4.8)
N02B, analgesics	120 (7.6)	18 (21.4)‡	128 (7.8)	11 (26.2)***
N06A, antidepressants	65 (4.1)	5 (6.0)	67 (4.1)	6 (14.3)**
N05B, anxiolytics	30 (1.9)	4 (4.8)	30 (1.8)	5 (11.9)**
N06C, psycholeptics	0 (0)	0 (0)	0 (0)	0 (0)

Values are number (percentage) unless otherwise specified.
[a]n < 1,673 for joint pain or n < 1,689 for muscle pain because of missing values.
[b]The median of the OHIP-14 sum score was 0 in each group; therefore, the proportions ≥ 1 and ≥ 4 are given.
[c]*P* value from median unbiased estimates.
IQR = interquartile range; OHIP-G14a = German Oral Health Impact Profile; ATC = Anatomical Therapeutic Chemical.
*$P < .05$; **$P < .01$; ***$P < .001$.

suffered from a lack of interest, tiredness, or loss of energy for a period of at least 2 weeks?'' For anxiety disorders, questions about panic attacks, generalized anxiety, agoraphobia, social phobia, and specific phobias were asked. The variables for depression and anxiety were dichotomized (none vs at least one positive answer). The performance of the CID-S in detecting the lifetime occurrence of mental disorders has been shown to be good, with an overall sensitivity of 80.7% and negative predictive value of 85.1%.[37]

Statistical Analyses

To determine the final model for control of confounders, the change-in-estimate method for binary logistic regression models was used. Adding the confounders led to a 10% change in the odds ratio (OR) of the unadjusted model.[39] The rms package[40] of the R Software was used for model diagnostics.[41] Model diagnostics were started using the Hosmer-Lemeshow test,[42] which was conducted by applying the methods described in Harrell's textbook.[43] Because joint pain and age had a nonlinear relationship, restricted cubic splines with four knots were used. The proportional odds assumption of the ordinal logistic regression used in the sensitivity analysis was evaluated using the Brant test[44] and graphically. As statistical authorities commonly recommend against performing power calculations after data have been collected, graphics proposed to assess retro-power were used.[45]

Results

Baseline Characteristics

After excluding missing values, 1,673 subjects for joint pain and 1,689 subjects for muscle pain with at least one traumatic event were available (Fig 1). The median (interquartile range) ages of the two groups were 58.9 (24.8) years and 59.1 (24.8) years, respectively. Subjects with pain had more PTSD B, C, and D criteria symptoms than subjects without pain (Table 1). Both PTSD and TMD outcomes were associated with sex, symptoms of depression and anxiety, marital status, and migraine headaches. Masticatory muscle pain was associated with arthritis, degenerative disc disease, and osteoporosis, whereas the associations with TMJ pain remained uncertain. The statistical models were adjusted for important confounders, including pain medication, psychiatric medication, and relevant general and psychiatric diseases.

Logistic Regression Analysis

The OR for TMJ pain was 2.56 for subjects with clinical PTSD compared to subjects without any D criterion symptoms or with only one D criterion symptom (Table 2; $P = .022$ for the final model). To increase statistical power, two strategies were taken: First, power was substantially increased by comparing subjects with at least one D criterion symptom to those with no D criterion symptoms (Fig 2); second,

Table 2 Relationship Between Joint Pain and Muscle Pain (Outcomes) and Posttraumatic Stress Experience (Exposure): Logistic Regression; OR (95% CI)

	Joint pain (n = 1,673)		
Successive adjustment	≥ 2 D symptoms vs < 2 D symptoms	≥ 1 D symptom vs no D symptoms	No. of D symptoms
Unadjusted	2.99** (1.38–6.51)	3.46*** (1.80–6.66)	1.50*** (1.22–1.84)
Age and sex	2.85** (1.29–6.28)	3.31*** (1.70–6.45)	1.46*** (1.18–1.80)
Traumatic events (final model)	2.56* (1.14–5.71)	3.04** (1.54–5.99)	1.41** (1.14–1.75)
OR for the no. of D symptoms			
1			1.41** (1.14–1.75)
2			2.00† (1.30–3.07)
3			2.82† (1.48–5.38)
4			3.99† (1.69–9.42)
5			5.64† (1.93–16.5)
School education	2.53* (1.13–5.67) n = 1,671	3.03** (1.53–5.98) n = 1,671	1.41** (1.13–1.75) n = 1,671
Fully adjusted[a]	2.75* (1.21–6.24) n = 1,626	3.22*** (1.62–6.41) n = 1,626	1.44** (1.16–1.79) n = 1,626
Alternative: Adjusted for age, sex, traumatic events, depressive symptoms, and anxiety symptoms	2.03 (0.87–4.72) n = 1,670	2.56* (1.24–5.25) n = 1,670	1.33* (1.06–1.68) n = 1,670

[a]Additionally adjusted for arthritis, degenerative disc disease, osteoporosis, and migraine.
OR = odds ratio; CI = confidence interval.
*P < .05; **P < .01; ***P < .001.

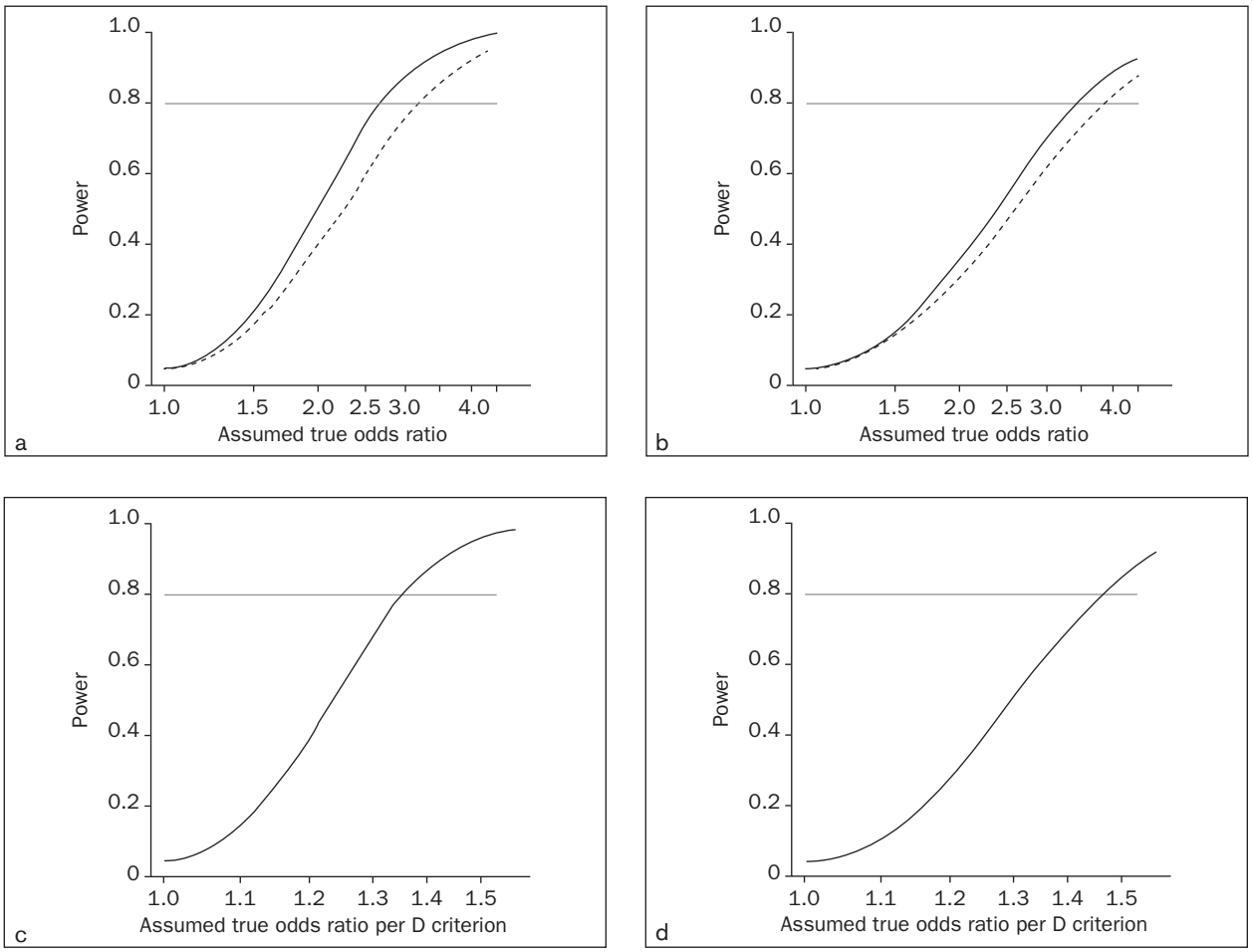

Fig 2 Retro-power[45] as a function of the true odds ratio (OR). *Top:* Dichotomous exposures for **(a)** joint pain and **(b)** muscle pain. Dashed line = clinical PTSD; solid line = at least one D criterion symptom. *Bottom:* Number of D criterion symptoms as exposure for **(c)** joint pain and **(d)** muscle pain.

Muscle pain (n = 1,689)		
≥ 2 D symptoms vs < 2 D symptoms	≥ 1 D symptom vs no D symptoms	No. of D symptoms
4.65*** (1.88–11.5)	3.97** (1.71–9.22)	1.57*** (1.22–2.02)
4.18** (1.68–10.4)	3.62** (1.55–8.47)	1.50** (1.16–1.94)
3.86** (1.51–9.85)	3.37** (1.41–8.04)	1.47** (1.13–1.91)
		1.47** (1.13–1.91)
		2.16** (1.27–3.65)
		3.17** (1.44–6.98)
		4.65** (1.62–13.3)
		6.83** (1.83–25.5)
3.85** (1.50–9.89) n = 1,687	3.33** (1.38–8.00) n = 1,687	1.45** (1.11–1.89) n = 1,687
3.61** (1.36–9.58) n = 1,641	3.28** (1.34–8.05) n = 1,641	1.43** (1.09–1.87) n = 1,641
3.47* (1.23–9.80) n = 1,686	3.10* (1.18–8.14) n = 1,686	1.42* (1.06–1.90) n = 1,686

the number of D symptoms was used as the exposure variable. Subjects with D criterion symptoms had a 3.04-fold increase in the odds of having joint pain compared to subjects without D criterion symptoms (Table 2). Regarding the number of D criterion symptoms, the OR per symptom was 1.41, which corresponds to an OR of 5.64 for subjects who had five D criterion symptoms compared to subjects with no D criterion symptoms. Further adjustments, including those for education, arthritis, degenerative disc disease, osteoporosis, and migraine headaches, did not lead to a change of > 10% in the OR (Table 2).

The OR for masticatory muscle pain was 3.86 for subjects having clinical PTSD compared to subjects without any D criterion symptoms or with only one D criterion symptom (Table 2; P = .005 for the final model). Here, the gain in power was only slight when changing from two D criterion symptoms to one (Fig 2). Subjects with D criterion symptoms had a 3.37-fold increase in the odds of having masticatory muscle pain compared to subjects without D criterion symptoms (Table 2). Regarding the number of D criterion symptoms, the OR per symptom was 1.47, which corresponds to an OR of 6.83 for subjects who had five D criterion symptoms compared to subjects who had no D criterion symptoms.

Sensitivity Analysis

When three categories of muscle pain were used instead of two, the trend for the proportion of subjects with D criterion symptoms on the indolent, uncomfortable, and painful rating scale was linear (72/1,545 = 4.7%; 5/55 = 9.1%; and 7/41 = 17.1%, respectively; departure from linearity: P = .606; P for linear trend < .001). In the ordinal logistic regression model adjusting for age, sex, and the number of traumatic events, subjects with D criterion symptoms were 2.8 times more likely to have a higher pain category than subjects without D criterion symptoms (95% CI: 1.5 to 5.3; P = .002). Further adjustment of variables, including education, arthritis, degenerative disc disease, osteoporosis, and migraine headaches, did not lead to a change of > 10% in the OR.

For TMJ pain, the trend across pain categories was not linear (67/1,428 = 4.6%; 4/117 = 3.4%; and 12/81 = 14.8% for indolent, uncomfortable, and painful, respectively; departure from linearity: P = .008).

Discussion

The present study showed a moderate to strong association between symptoms of PTSD and signs of TMD in the general population. Signs of TMD were defined with a standardized clinical functional analysis with palpation, and PTSD was defined with a structured clinical interview. The statistical models were adjusted for pain medication, psychiatric medication, and relevant general and psychiatric diseases.

A relationship between PTSD symptoms and signs of TMJ or muscle pain may be explained by the following reasons. PTSD may initiate muscular hyperactivity, which may lead to altered muscle and TMJ mechanics and may further result in TMD muscle and joint pain.[7] TMD pain might also be related to an abnormal pain processing in the trigeminal system,[46] which may be triggered by PTSD.

PTSD, but not the traumatic events themselves, seemed to affect TMD pain, consistent with studies linking TMD pain to symptoms highly indicative of PTSD.[20,47] The number of traumatic events was strongly related to PTSD but only weakly related to pain in the present study. Because the number of traumatic events is also a risk factor for TMD pain (eg, via depressive symptoms), appropriately estimating the confounding effect of the number of traumatic events on the relationship between TMD signs and PTSD is crucial. However, there is an overlap between symptoms of PTSD and those of depression/anxiety disorders, which may affect signs of TMD.[14] This overlap also exists in treatment with tricyclic antidepressants. Tricyclic antidepressants and serotonin reuptake inhibitors are used in the therapy of TMD pain,[7] as well as in the therapy of PTSD and depression.[14]

For the clinical diagnosis of PTSD (DSM-IV), in addition to the symptoms of re-experiencing (B criterion) and avoidance (C criterion), at least two symptoms of hyperarousal were required (D criterion). Symptoms of hyperarousal refer to the physiologic manifestations of PTSD, such as insomnia, irritability, impaired concentration, hypervigilance, and an increased startle reaction.[14] Symptoms of hyperarousal indicate a higher degree of the severity of PTSD; thus, these results suggest that PTSD is linked to signs of TMD and that subclinical forms of PTSD may be associated with signs of TMD as long as symptoms of hyperarousal are present. These results are consistent with previous findings that hyperarousal symptoms had direct and indirect effects on the severity of orofacial pain.[23] Even in standardized inventories with arbitrary scores and thresholds, researchers seldom agree on the cutoff points, and thus subclinical associations below these thresholds are not described. These thresholds may have restricted the knowledge of mental health in population studies, and PTSD exists as a continuum rather than as a dichotomous element.[48] Problems caused by the dichotomization of continuous variables are well described[49] and can affect decision-making in patients seeking treatment in clinical settings, including orofacial pain centers. de Leeuw et al and Cyders et al concluded that PTSD screening should be included as part of a routine psychometric test battery in TMD patients.[20,23]

In contrast to clinical samples recruited in orofacial pain centers,[23] the interest of the present epidemiologic study was primarily in etiology rather than in treatment. Therefore, TMD was defined on the basis of criteria that have nothing to do with exposure.[39] In this study, the clinical TMD examination protocol followed the guidelines of the American Association of Orofacial Pain. This protocol was the most common diagnostic tool at that time.[33] The RDC/TMD and the diagnostic criteria for TMD (DC/TMD)[50] are defined in terms of an exposure (eg, DC/TMD diagnosis "headache attributed to TMD"). Defining TMD pain in terms of an exposure may be a common mistake[51] when analyzing the association of TMD pain with mental disorders such as PTSD. Mixing signs and symptoms discounts the Bradford-Hill criterion of specificity, and clusters of signs and symptoms may not define a common pathophysiology.[52] Therefore, the outcome variable, TMD pain, was divided into two end points that do not mix signs and symptoms. This has been reported to be advantageous for epidemiologic reasons.[53] The 2.56-fold higher OR for joint pain for subjects having clinical PTSD in the present study is similar to the 3-fold–increased risk for symptoms of TMD that has been described in female twins with PTSD.[21]

This study had several limitations. First, participants were Caucasian, which limits the generalizability of the results. A second limitation was the small number of muscle pain events in the binary logistic regression model; therefore, the results of these analyses should be interpreted with caution. A potential effect of overlap between depressive/anxiety disorders and PTSD on TMD pain cannot be fully excluded; however, the exposure effect of symptoms of hyperarousal (PTSD D criterion) on TMD pain was reduced when adjusting for depressive symptoms and anxiety symptoms, and a model favoring an effect of PTSD on depressive or anxiety symptoms was supported. Also, misclassification, as well as unknown confounding, cannot be fully excluded.

There are also several strengths of the study's analyses. One important difference between this study and other population-based studies is that the signs of TMD were diagnosed with a standardized clinical examination. Compared to patient studies, the general population sample avoided self-selection, a common source of bias, and facilitated the comparison of pain in subjects with and without a traumatic experience.

Conclusions

In the present study, a moderate to strong exposure effect of clinical PTSD on TMD pain in the general population was found. These findings indicate that there is clinical relevance for clinicians to have knowledge about PTSD and the exposure effect on TMD pain in the general population in clinical practice. The development of therapeutic algorithms for chronic TMD pain patients with PTSD symptoms should include psychological interventions. In a period of international migration and military foreign assignments, this exposure effect is likely to become more important in the future.

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