Article

Predicting Posttraumatic Stress Symptoms From Pretraumatic Risk Factors: A 2-Year Prospective Follow-Up Study in Firefighters

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Objective: Most studies focusing on risk factors for posttraumatic stress disorder (PTSD) have used retrospective study designs. Only a small number of studies have prospectively examined risk factors in the immediate aftermath of trauma exposure in predicting PTSD symptoms. The purpose of this study was to identify predictive risk factors for posttraumatic stress symptoms and comorbid psychopathological symptoms present during the time before exposure to traumatic stress in a high-risk population.

Method: Forty-three professional firefighters were assessed immediately after basic training (baseline) and at 6, 9, 12, and 24 months after entry into firefighter service. Subjects were screened for psychopathological symptoms, including symptoms of PTSD, depression, and anxiety. Subjects were also characterized with regard to personality traits such as self-efficacy, hostility, and alexithymia. Neuroendocrine activity was assessed by examination of awakening and diurnal salivary cortisol profiles and 24-hour urinary catecholamine excretion. Multiple linear regression analysis was used to analyze posttraumatic stress symptoms at 24-month follow-up as a function of pretraumatic characteristics.

Results: A high level of hostility and a low level of self-efficacy at baseline accounted for 42% of the variance in posttraumatic stress symptoms after 2 years. Subjects who had both risk factors at baseline showed a significant increase in measures of PTSD symptoms, depression, anxiety, general psychological morbidity, global symptom severity, and alexithymia during the 2-year period. Biological characteristics were not predictive of the development of psychopathological symptoms.

Conclusions: These results suggest that specific personality traits may constitute markers of vulnerability to the development of psychopathological symptoms after trauma exposure. Early identification of preexisting risk factors is needed to provide effective prevention and intervention for individuals who are at risk of developing trauma-related disorders.

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Posttraumatic stress disorder (PTSD) is a mental disorder that potentially follows an event in which the individual experienced, witnessed, or was confronted with either actual or threatened loss of life or serious injury invoking a response of fear, helplessness, or horror. According to DSM-IV, PTSD symptoms are subdivided into three categories: reexperiencing of the trauma, numbing of affect and avoidance of trauma-related stimuli, and symptoms of excessive arousal not present before the event. Since the introduction of PTSD to the psychiatric nomenclature, a growing amount of research has centered on diagnosis, course, and treatment of the disorder. However, only a small subset of individuals who have been exposed to a traumatic event goes on to develop PTSD or other disorders (e.g., major depression, anxiety disorders) (1). The estimated lifetime prevalence of PTSD ranges from 1.3% in Germany (2) to 7.8% in the United States (3). In contrast, 89.6% of citizens in the United States are exposed to at least one traumatic event at some time in their lives (4). Thus, PTSD is a possible but not inevitable consequence of trauma exposure. Because initial evidence suggests the potential benefits of early intervention shortly after trauma (5–7), accurate identification of specific risk and protective factors is needed to provide effective treatment to those who are likely to develop long-term trauma-related psychopathology.

Aside from the most salient predictor of PTSD, which is the nature of the traumatic event itself, three other risk factors were consistently identified across studies in a meta-analysis by Brewin et al. (8): psychiatric history, family history of mental disorders, and childhood abuse. In addition, personality traits (e.g., hostility, neuroticism, self-efficacy) were also identified as predictors of PTSD symptoms (8, 9). However, it is noteworthy that the vast majority of previous studies have used retrospective designs with respect to possible risk factors, and the poten-

tial for distortion of such factors in cross-sectional research is well known from a methodological point of view. Moreover, retrospective data of trauma survivors are influenced by typical PTSD symptoms, such as avoidance and amnesic or dissociative symptoms. Thus, a putative risk factor may merely be a consequence of the disorder, not one of its causes.

Until recently, few studies prospectively examined the development of mental disorders after exposure to trauma. In most of these studies, psychological and biological data were collected in the immediate aftermath and at subsequent time points after trauma exposure (e.g., assault, motor vehicle accident) to identify mechanisms that are predictive of PTSD symptoms. It is interesting to note that the salient predictors of PTSD known from retrospective studies seem to have poor predictive value for the development of the disorder when they are assessed in a prospective design (10). For example, discriminant function analysis failed to show effects of past psychiatric history, prior trauma, or intrusive symptoms in victims of motor vehicle accidents in the immediate aftermath of a trauma (11, 12). In contrast, biological variables in the acute peritraumatic phase have been shown to more accurately predict chronic PTSD (1). For example, lower cortisol levels (11, 13) and higher resting heart rates (14, 15) shortly after motor vehicle accidents were shown in persons who developed PTSD at a follow-up time, relative to those who did not.

However, these prospective posttraumatic data do not allow the identification of predisposing factors. Is it the trauma itself or pretraumatic vulnerability that gives rise to the altered biological and psychological mechanisms immediately after trauma? And if these early posttraumatic mechanisms have been shown to have high predictive value for the development of PTSD symptoms and other mental disorders, would the identification of preexisting risk factors allow a better understanding of the development of trauma-related disorders? The analysis of pretraumatic risk factors may best be carried out with a prospective, longitudinal study design that includes data from the period before exposure to trauma, which are used to determine whether any of the factors predict subsequent PTSD symptoms. Whereas pretraumatic factors of primary victims (e.g., persons who have experienced rape or a motor vehicle accident) are very difficult to establish conclusively for methodological reasons, members of high-risk populations for trauma-related disorders who are often exposed to traumatization provide an adequate sample. Professional firefighters are regularly engaged in intense traumatic events, including exposure to gruesome injuries or death and unpredictable, dangerous situations (16–21). The estimated prevalence of PTSD is 22.2% in American firefighters and 17.3% in Canadian firefighters (22). Similarly, an estimated 18.2% of German firefighters met the diagnostic criteria for PTSD (23). In view of the fact that a community study found the highest risk of PTSD in victims of assaultive violence to be 20.9% (4), it is clear that firefighters represent a population at high risk for the development of PTSD symptoms.

Although there is still considerable need for a better understanding of the development of chronic psychopathology after a traumatic event, to date, even less attention has been given to the underlying preexisting vulnerability mechanisms. In a prospective, longitudinal study design, subjective (personality traits, psychopathological symptoms) and neuroendocrine (salivary cortisol, urinary catecholamines) characteristics were repeatedly assessed. In this study we sought to answer the question: What characteristics present at the time before exposure to traumatic stress may predict PTSD symptoms and other psychopathological symptoms in a high-risk population over the course of 2 years?

Method

Participants and Procedure

Forty-three male probationary professional firefighters (mean age=25.6 years, SD=3.5) enrolled in the study immediately after completing basic training at the fire academy. All subjects underwent a medical examination to screen out chronic diseases, mental disorders (including PTSD and past trauma history), use of medication, and drug or alcohol abuse before entering the study. Four of the original 47 subjects were excluded: three met the criteria for a mental disorder (according to assessment with the PTSD Symptom Scale [24] and the General Health Questionnaire [25]) and one met the criteria for alcohol abuse. Female firefighters were not included in the study because only one female firefighter was present during the period of recruitment. The study was approved by the institutional review board of the University of Trier. All subjects provided written informed consent before participation, and all were informed of their right to discontinue participation at any time.

After an initial screening that determined their eligibility, participants were given detailed verbal explanations of the study procedures. They then received the study pack for the first study time point. It contained full standardized written instructions for the study questionnaires and saliva and urine measures (see later description). The study pack also contained saliva sampling tubes and a container for urine collection. Participants were assessed after completing basic training (baseline) and at 6, 9, 12, and 24 months after entry into the fire departments. Immediately after basic training, probationary firefighters take up postings at operational fire stations. Particularly between 6 and 12 months after job entry, the fire departments endeavor to confront the probationary firefighters intensively with stressful on-duty events (e.g., exposure to deaths of others and to unpredictable and life-threatening situations) in order to test their eligibility for the job.

The second day of 2 consecutive days off within a defined 2-week period was used for psychological and endocrine assessments. The 2-week period was necessary in order to account for irregular changes of shift and vacation. All study materials, including completed questionnaires and saliva and urine samples, were immediately transferred to the laboratory.

Psychological Measures

At all five study time points, participants completed questionnaires to measure demographic items, personality characteristics, and psychopathological symptoms. The validated German versions of the following questionnaires were included: the PTSD

Symptom Scale (24), the General Health Questionnaire (25), the Zung Self-Rating Depression Scale (26), the State-Trait Anxiety Inventory (27), the SCL-90-R (28), and the Toronto Alexithymia Scale (29, 30). Self-efficacy was assessed by using the Inventory on Competence and Control Beliefs (31). All of these questionnaires are widely used and have shown satisfactory internal consistency and validity.

The PTSD Symptom Scale (24) is a self-report rating scale designed to assess the presence and severity of PTSD symptoms on a 4-point scale. The questionnaire is scored as three subscales rating reexperiencing (five items), avoidance (seven items), and arousal (five items) symptoms, according to the DSM criteria. PTSD is diagnosed if at least one reexperiencing symptom, three avoidance symptoms, and two arousal symptoms are endorsed on the scale by firefighters who were traumatized at least 1 month before the examination. According to Foa et al. (24), a symptom rates as present if the PTSD Symptom Scale item corresponding to the symptom is scored one or greater. Subsyndromal PTSD can be diagnosed if the reexperiencing symptom cluster is present plus either the avoidance or the arousal cluster (23, 32). The PTSD Symptom Scale is recommended for use as a continuous measure (24) and for the assessment of PTSD symptoms in high-risk populations (7, 33).

The General Health Questionnaire (25) is a standard screening measure based on 28 items that is used for detecting individuals with a diagnosable mental disorder and has been widely validated. The questionnaire consists of subscales for somatic symptoms, anxiety/insomnia, social dysfunction, and severe depression. In the present study, the General Health Questionnaire scoring method (0-0-1-1) was applied so that 1 point was given for each affirmative answer. The General Health Questionnaire has been recommended for screening general psychological morbidity in the high-risk population of firefighters (23).

The Zung Self-Rating Depression Scale (26) has 20 items describing depressive symptoms on a 4-point scale. Scores on the Zung Self-Rating Depression Scale indicate levels of depressive symptoms that may be of clinical significance. Several studies have established this questionnaire as a reliable and valid instrument for measuring depressive symptoms (34).

Anxiety was measured with the trait anxiety scale of the State-Trait Anxiety Inventory (27), which has 20 items that are rated on a 4-point scale. Trait anxiety denotes individual differences in anxiety proneness and refers to a general tendency to respond with anxiety to perceived threats in the environment.

The SCL-90-R (28) is a multidimensional self-report instrument designed to screen for a broad range of psychological problems and symptoms of psychopathology. The inventory contains nine primary symptom scales and three global indices with a total of 90 items, each of which is rated on a 5-point scale indicating the degree of distress associated with each symptom.

Alexithymia was assessed by using the self-report Toronto Alexithymia Scale (29, 30), which is composed of 20 items rated on a 5-point scale to measure the difficulty of recognizing and verbalizing emotions.

Self-efficacy was assessed by using the Inventory on Competence and Control Beliefs (31), which consists of 32 items rated on a 6-point scale. Self-efficacy is a predictor of the individual's perception of competence and the capacity to act autonomously and efficiently. An example of an item of this scale is "I can pretty much determine what will happen in my life." The reliability and validity of this questionnaire are well established (35, 36).

Endocrine Measures

Salivary cortisol. Recent studies have found the measurement of cortisol as an indicator for adrenocortical activity to be of high predictive value for the development of PTSD (for review, see references 37, 38). Numerous studies indicate that salivary cortisol is considered a reliable and valid measure of the biologically active, or unbound, fraction (39), with high correlations between salivary and plasma free cortisol (40, 41). The study packs for all five time points contained full standardized written instructions and eight prelabeled saliva sampling tubes (Salivette; Sarstedt, Rommelsdorf, Germany). Participants were instructed to collect saliva immediately upon awakening and at 30, 45, and 60 minutes thereafter. This group of samples constituted the awakening cortisol profile. Four additional samples were provided over the course of a day at 8:00 a.m., 11:00 a.m., 4:00 p.m., and 8:00 p.m. This group of samples constituted the diurnal cortisol profile. Participants were instructed to collect their saliva by chewing the cotton dental swab from the Salivette for 60 seconds. For all samples, subjects were asked to refrain from smoking, eating, or drinking anything but water for at least 30 minutes before saliva collection. Samples were kept in freezers in the subjects' residences until delivery to the laboratory. The Salivette tubes were stored in the laboratory at –20°C until they were required for biochemical analysis. Before the samples were assayed for free cortisol, they were thawed and centrifuged at 3000 rpm for 10 minutes to obtain 0.5–1.0 ml clear saliva with low viscosity. This procedure has been shown to be valid in assessing both awakening and diurnal cortisol profiles in human research (e.g., references 36, 42). The free cortisol concentration in saliva was analyzed by using a time-resolved immunoassay with fluorescence detection, as described previously (43). The limit of detection was 0.5 nmol/liter. The inter- and intra-assay coefficients of variation were below 12% and 10%, respectively.

Urinary catecholamines. Studies of alterations of the sympathetic nervous system in PTSD have shown hyperadrenergic states with higher 24-hour urinary catecholamine excretion in PTSD patients, relative to comparison subjects (44, 45). At all five time points in the present study, written instructions and a polypropylene container for urine collection were mailed to the subjects. The subjects were instructed to urinate into the container during the 24-hour collection period and refrigerate the sample until delivery to the laboratory. After the evaluation of volume, aliquots were frozen at –80°C until assayed. Norepinephrine and epinephrine concentrations were assayed by high-performance liquid chromatography with electrochemical detection (Chromsystems, Munich, Germany). The inter- and intra-assay coefficients of variation were below 5% and 4%, respectively.

Data Analyses

Initial one-way analyses of variance (ANOVAs) with repeated measures were conducted to examine the course of psychometric and biological characteristics in the entire group of subjects. The areas under the curve were calculated with the trapezoid formula, aggregating the four awakening cortisol levels and the four diurnal cortisol levels, respectively (46). To determine which variables at baseline might predict PTSD symptoms (PTSD Symptom Scale) 24 months after regular exposure to traumatic events, we first performed bivariate correlations. To avoid suppression effects and multicollinearity in the regression analysis (47, 48), only baseline variables that were significantly correlated with PTSD symptoms at follow-up and not correlated among each other were included as independent variables in the subsequent regression analysis. To cover the range of PTSD symptoms in further analyses, the PTSD Symptom Scale was used as a continuous measure (8, 24). Finally, in order to elucidate which factors most strongly predict higher levels of PTSD symptoms over the course of 2 years, we used a stepwise multiple linear regression analysis with scores on the PTSD Symptom Scale in the 2-year follow-up as the dependent variable and scores on baseline variables (identified through bivariate correlations) as the independent variables. To determine how risk factors identified by regression analysis alter the course of psychological and biological characteristics, individuals were divided into high- and low-risk

TABLE 1. Psychometric and Biological Characteristics of Male Firefighters at Baseline (Immediately After Basic Training) and Over the First 24 Months After Entry Into Firefighter Service

	Baseline (N=43)		6 Months (N=38)		9 Months (N=37)		12 Months (N=34)		24 Months (N=36)	
Characteristic	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Body weight (kg)[a]	78.33	9.76	78.89	9.13	78.77	8.99	80.37	9.45	80.49	9.48
Psychiatric symptoms (General Health Questionnaire total score)	13.92	5.56	15.00	8.05	16.14	10.53	15.18	10.94	15.19	9.53
Global severity (SCL-90-R global severity index)	0.20	0.15	0.18	0.17	0.23	0.32	0.20	0.33	0.24	0.35
Hostility (SCL-90-R hostility subscale score)	0.18	0.22	0.12	0.25	0.24	0.44	0.27	0.61	0.25	0.54
Trait anxiety (State-Trait Anxiety Inventory score)	30.24	5.71	31.55	7.70	31.43	8.36	31.44	10.32	32.36	9.10
Depression (Zung Self-Rating Depression Scale score)	34.44	5.17	36.70	7.95	37.50	9.34	37.32	10.50	37.72	9.41
Alexithymia (Toronto Alexithymia Scale score)	41.13	6.70	42.27	8.30	42.92	6.69	40.49	9.63	42.65	11.52
Self-efficacy (Inventory on Competence and Control Beliefs score)	67.07	6.17	68.19	6.40	68.14	8.55	68.15	8.09	69.40	8.48
Awakening salivary cortisol profile (area under the curve, nmol/liter)[b]	18.47	6.38	17.60	5.10	18.94	6.95	18.64	7.90	20.33	8.79
Diurnal salivary cortisol profile (area under the curve, nmol/liter)[c]	103.41	47.21	101.18	43.74	101.10	38.66	119.11	50.49	113.24	45.37
Urinary epinephrine (µg/24 hours)	9.47	3.76	8.32	2.97	8.89	2.86	9.94	5.61	9.96	3.72
Urinary norepinephrine (µg/24 hours)	38.97	11.21	36.98	11.01	40.60	14.25	39.54	17.07	38.60	13.41

[a] Significant increase of body weight over the course of the study ($F=3.08$, $df=2.7, 74.4$, $p<0.05$).
[b] The area under the curve aggregates the four salivary cortisol levels measured immediately after awakening and at 30, 45, and 60 minutes thereafter.
[c] The area under the curve aggregates the four salivary cortisol levels measured at 8:00 a.m., 11:00 a.m., 4:00 p.m., and 8:00 p.m.

groups by median split of the baseline scores for the predictors. Differences in the course of psychological and biological characteristics between the high- and low-risk groups were then examined by using two-way ANOVAs with repeated measurement (group-by-time [repeated factor: five time points]). Where the Mauchly test of sphericity indicated heterogeneity of covariance, we verified repeated-measures results with Greenhouse-Geisser corrections. The statistical significance level was set at 5% for two-sided tests.

Results

Description of Subjects

Participants were assessed after completing basic training (baseline) and at 6, 9, 12, and 24 months after entry into the fire departments. None of the subjects met the criteria for PTSD at baseline. At 24-month follow-up, seven subjects (16.3%) met the criteria for PTSD and eight subjects (18.6%) met the criteria for subsyndromal PTSD according to the PTSD Symptom Scale. Table 1 summarizes data on the subjects' psychometric and biological characteristics over the course of the study. There was a significant increase of body weight in study participants ($F=3.08$, $df=2.7, 74.4$, $p<0.05$). All other psychometric and biological variables did not significantly change in the total group during the course of the study. There was no correlation between the number and severity of traumatic events and PTSD symptoms.

Predicting PTSD Symptoms From Characteristics Before Trauma Exposure

Bivariate correlations were used to assess the relationship between variables before entry into the fire departments (baseline) and PTSD symptoms 24 months later. The bivariate correlations demonstrated that the PTSD Symptom Scale score at 24-month follow-up was negatively correlated with baseline self-efficacy (assessed with the Inventory on Competence and Control Beliefs) ($r=-0.40$, $df=35$, $p=0.02$) and positively correlated with baseline hostility (assessed with the SCL-90-R) ($r=0.58$, $df=35$, $p<0.001$), baseline general psychological morbidity (assessed with the General Health Questionnaire) ($r=0.45$, $df=32$, $p=0.01$), and baseline obsessive-compulsive symptoms (assessed with the SCL-90-R) ($r=0.48$, $df=35$, $p=0.004$). These variables were included as independent variables in the regression analysis in which the score on the PTSD Symptom Scale at 24-month follow-up was the dependent variable (see Data Analyses).

The results obtained in the stepwise multiple linear regression analysis revealed two significant predictors of PTSD symptoms after 2 years of service in a fire department. A high level of hostility (assessed with the SCL-90-R) and a low level of self-efficacy (assessed with the Inventory on Competence and Control Beliefs) before job entry significantly predicted higher PTSD symptom levels at 2-year follow-up. It is important to note that there was no correlation between the two variables ($r=-0.04$, $df=42$, $p=0.81$). With regard to the direction of the regression effects, self-efficacy received a negative beta weight, indicating a negative relation to PTSD symptoms. In contrast, hostility had a positive effect on PTSD symptoms. The total model explained 42% of the variance in PTSD symptoms after 2 years ($F=13.37$, $df=2, 32$, $p<0.001$). The results of the stepwise multiple linear regression analysis are depicted in Table 2.

Course of Psychological and Biological Characteristics in Firefighters With High and Low Risk for PTSD Symptoms

To further investigate the predictive value of hostility and self-efficacy for the development of PTSD symptoms

TABLE 2. Stepwise Multiple Linear Regression Analysis of Pretraumatic Risk Factors That Are Predictive of PTSD Symptoms at 24-Month Follow-Up in Male Firefighters (N=34)[a]

Variable	R^2	Corrected R^2	ΔR^2	ΔF	Δp	Standardized Beta	t	df	p
Hostility (SCL-90-R hostility subscale score)	0.34	0.32	0.34	16.78	0.000	0.54	4.15	33	<0.0001
Self-efficacy (Inventory on Competence and Control Beliefs score)	0.46	0.42	0.12	6.93	0.013	–0.35	2.63	32	<0.01

[a] Model: F=13.37, df=2, 32, p<0.001.

and other comorbid symptoms, high- and low-risk groups, as determined by median split of the baseline scores of both predictors, were created. The high-risk group (N=11) had a mean hostility score of 0.33 (SD=0.19) and a mean self-efficacy score of 61.55 (SD=5.09) after completing basic training (baseline). The low-risk group (N=31) had a mean score of 0.12 (SD=0.21) for hostility and a mean score of 69.03 (SD=5.32) for self-efficacy. Subjects in the high-risk group fulfilled the criteria for both a high level of hostility and a low level of self-efficacy. All other subjects were assigned to the low-risk group. Two-way ANOVAs with repeated measurement that included the two groups as a between-subject factor were performed to assess differences in the course of psychopathological symptoms and biological characteristics (Figure 1). No significant differences in baseline levels were observed between the two groups.

There were significant main effects of time (F=2.97, df=2.81, 70.17, p<0.05) and group (F=11.55, df=1, 25, p<0.01) and a significant two-way interaction effect (group-by-time: F=3.70, df=2.81, 70.17, p<0.05) on the PTSD Symptom Scale score, with an increase of PTSD symptoms in the high-risk group only (Figure 1). A two-way ANOVA with repeated measurement revealed a significant main effect of group (F=16.67, df=1, 25, p<0.001) and an interaction effect that approached significance (group-by-time: F=2.69, df=2.82, 70.44, p=0.056) on the General Health Questionnaire score (Figure 1). For the Zung Self-Rating Depression Scale score, significant main effects of time (F=6.47, df=2.61, 73.11, p<0.001) and group (F=12.85, df=1, 28, p<0.001) and a significant two-way interaction effect (group-by-time: F=5.39, df=2.61, 73.11, p<0.01) were found (Figure 1), with no changes in the low-risk group and a marked increase over time in the high-risk group. For the State-Trait Anxiety Inventory score, there was a significant main effect of group (F=5.10, df=1, 28, p<0.05) and an interaction effect that approached significance (group-by-time: F=2.84, df=2.54, 71.19, p=0.052) (Figure 1). For the global severity index of the SCL-90-R, a significant main effect of group (F=7.20, df=1, 27, p<0.05) and a significant interaction effect (group-by-time: F=4.62, df=2.00, 54.10, p<0.05) were found (Figure 1). For the Toronto Alexithymia Scale score, a two-way ANOVA with repeated measurement revealed a significant main effect of group (F=14.42, df=1, 17, p<0.001) and a significant interaction effect (group-by-time: F=2.64, df=4, 68, p<0.05) (Figure 1). No significant differences in awakening and diurnal profiles of salivary cortisol were observed between groups (Figure 1). In addition, there were no significant changes in urinary catecholamines during the course of the study in the high- versus the low-risk group.

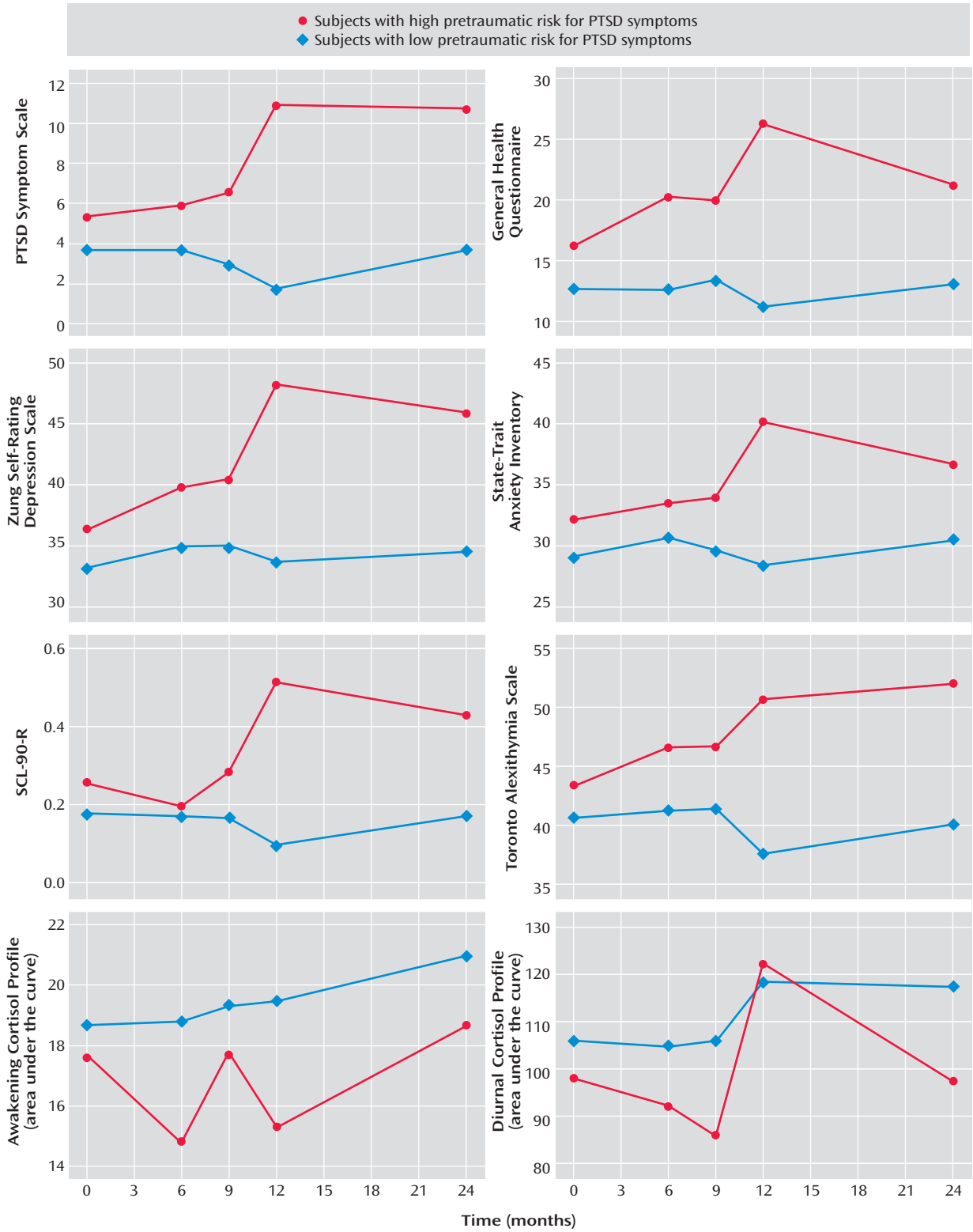
Overall, the firefighters with both risk factors—a high hostility score and a low self-efficacy score—showed a general increase in all psychopathological symptoms assessed during the 2-year period of prospective measurement.

Discussion

Although exposure to trauma is common, PTSD and other mental disorders after trauma are relatively rare. The core methodological issue in the growing field of research on traumatic stress is to test which factors precede psychopathological symptoms that emerge after trauma in order to allow early and specific diagnosis and intervention. The best method for identifying variables that increase the risk for trauma-related disorders may be to administer a battery of measures to a large number of individuals before their exposure to trauma and to determine whether any measures predict subsequent PTSD symptoms (9). Professional populations at high risk for trauma-related disorders (e.g., firefighters, members of the military) are regularly engaged in traumatic events and thus provide model groups in which to explore preexisting differences that constitute risk factors for PTSD symptoms.

To our knowledge, the current study is the first to investigate prospectively the predictive power of both psychological and biological characteristics before trauma exposure in the development of subsequent posttraumatic stress symptoms. The results of the multiple regression analysis show that the combination of preexisting high levels of hostility and low levels of self-efficacy is a strong predictor of the development of PTSD symptoms in the high-risk population of firefighters. The presence of both risk factors at baseline accounted for 42% of the variance in posttraumatic stress symptoms at 2-year follow-up. Moreover, firefighters with both of these personality characteristics at baseline had a steady increase during the 2-year period in scores on measures of PTSD symptoms, depression, anxiety, general psychological morbidity, global severity of symptoms, and alexithymia. The strongest increase in all of the psychopathological symptoms assessed took place between 6 and 12 months after job entry (Figure 1). It is noteworthy that during that period, the fire departments endeavored to confront the probationary firefighters with stressful on-duty events in order to test their eligibility for the job (see Method). In

FIGURE 1. Mean Scores on Measures of Psychopathological Symptoms and Cortisol Levels in Male Firefighters With High and Low Pretraumatic Risk for the Development of PTSD Symptoms Over 24 Months of Firefighter Service[a]



[a] Significant interaction effect (group-by-time) on PTSD Symptom Scale score ($p<0.05$), Zung Self-Rating Depression Scale score ($p<0.01$), SCL-90-R score ($p<0.05$), and Toronto Alexithymia Scale score ($p<0.05$); significant main effect of time on PTSD Symptom Scale score ($p<0.05$) and Zung Self-Rating Depression Scale score ($p<0.001$); significant main effect of subject group on PTSD Symptom Scale score ($p<0.01$), General Health Questionnaire score ($p<0.001$), Zung Self-Rating Depression Scale score ($p<0.001$), State-Trait Anxiety Inventory score ($p<0.05$), SCL-90-R score ($p<0.05$), and Toronto Alexithymia Scale score ($p<0.001$) (two-way analysis of variance with repeated measurement).

contrast, subjects with either low levels of hostility or high levels of self-efficacy or both protective traits showed no increase in psychopathological symptoms, suggesting a significant effect of these personality factors on the development or prevention of stress-related symptoms.

The present data support and extend the clinical evidence regarding the role of personality traits in PTSD. Higher levels of hostility and anger have been associated with the development of PTSD symptoms in combat veterans; victims of violent crime, sexual assault, and accidents; and political prisoners (49–63). For example, anger accounted for more than 40% of the variance in PTSD symptoms in Vietnam veterans (60). Furthermore, lower levels of self-efficacy have previously been related to PTSD symptoms (64–66). Individuals with PTSD report lower self-efficacy levels than healthy comparison subjects, although traumatized individuals without PTSD do not differ in self-efficacy from comparison subjects (66). However, all of these studies of the predictive power of alleged risk factors began only after subjects had been exposed to trauma. The design of such studies makes it difficult to differentiate between consequences and causes.

As yet, only a small number of prospective, longitudinal studies have been conducted in this area, and they have primarily examined archival data (e.g., military records) collected pretrauma. In combat veterans, specific preexisting personality traits were shown to predict PTSD symptoms (67–69). Schnurr et al. (69) found that higher scores on the MMPI paranoia, hypochondriasis, psychopathic deviate, and masculinity-femininity scales predicted PTSD symptoms in male college graduates who later served in the Vietnam War. Bramsen et al. (67) reported that higher scores on a personality measure of negativism (akin to neuroticism) predicted subsequent PTSD symptoms among Dutch veterans who took part in the United Nations Protection Force mission in the former Yugoslavia. These initial prospective findings suggested that pretrauma personality traits are predictive of later development of PTSD symptoms after trauma exposure. Moreover, there is evidence that lower intelligence levels precede rather than follow the development of PTSD symptoms in combat veterans (70).

The identification of risk factors may provide clues regarding underlying mechanisms and could help in building new strategies to prevent the development of a disorder (71). It is surprising that little attention has been directed toward the role of protective or resilience factors against stress-related psychopathology. For example, individuals with low hostility ratings may be those who have better social coping abilities. A possible consequence of a high level of hostility, on the other hand, is social isolation or lack of social support. It should be noted within this context that recovery from PTSD is significantly influenced by the ability to preserve social support networks (8, 72–77), and in turn, social support might be an important factor for maintaining high levels of self-efficacy (73). As self-efficacy refers to an individual's feeling of confidence that they can perform a desired action (78–80), individuals with a high level of self-efficacy may be able to impose meaning on their traumatic experiences, thereby fostering recovery from them. Conversely, low self-efficacy might render life more unpredictable and uncontrollable from the perspective of the survivor of a trauma, thereby increasing the risk for long-term trauma-related psychopathology. Accordingly, the intense exposure to stressful events experienced by probationary firefighters 6–12 months after job entry led to a strong increase in all psychopathological symptoms in the firefighters who had a high level of hostility and a low level of self-efficacy, while the low-risk group showed no changes during this period (Figure 1). Future prospective studies should further explore powerful protective psychological factors (e.g., social support, self-efficacy), other personality factors, and possible underlying neurobiological mechanisms (e.g., neuropeptide oxytocin) in the development of stress-related symptoms (81–83).

In the present study, we did not find significant alterations in salivary cortisol and urinary catecholamines. Although awakening cortisol concentrations were consistently lower in the high-risk group of firefighters (those with a high level of hostility and a low level of self-efficacy) than in the low-risk group during the 2-year period, the difference did not reach statistical significance, possibly owing to the small number of subjects. Most studies of chronic PTSD have demonstrated that PTSD is associated with distinct endocrine modifications, primarily involving a highly sensitized hypothalamic-pituitary-adrenal (HPA) axis characterized by decreased basal cortisol levels and increased negative feedback regulation (e.g., references 37, 84–88). These studies raise the question of when in the course of adaptation to trauma are low basal cortisol levels first observable. For example, McFarlane et al. (11) demonstrated that subjects who had developed PTSD 6 months after a motor vehicle accident had significantly lower cortisol levels within hours after the trauma, compared to subjects who subsequently developed major depression or those who did not develop a mental disorder. Resnick et al. (89) found lower cortisol levels immediately after rape only in women with a prior history of rape or assault, although cortisol levels did not predict the subsequent development of PTSD in these women. However, the course of cortisol levels pretrauma has not yet been examined. One possible explanation for the difference in our endocrine findings, compared with those of previous studies, might be a differential extent of psychopathological symptoms. In the present study, we used a continuous measure to cover the range of PTSD symptoms (e.g., references 90–94). Future longitudinal studies should additionally use standardized diagnostic interviews at all time points to measure symptoms of

PTSD. Moreover, we did not measure PTSD symptoms related to a specific traumatic event. Despite these limitations, our results do suggest that both cortisol and catecholamine levels before trauma exposure did not predict the development of posttraumatic stress symptoms over the course of 2 years. Obviously, additional prospective, longitudinal studies that use neuroendocrinological and neuroimaging techniques and that include large study groups and start before exposure to trauma are needed to further evaluate the course of biological mechanisms in the adaptation to trauma.

An important question to be raised is to what extent the current data may be generalized to other populations. The largest group of traumatized individuals in which PTSD symptoms have been studied is male combat veterans. The present study was conducted in a population of male professional firefighters. It is important to note that the risk factors discovered in male high-risk populations cannot be applied directly to other groups, including the general population, assault and rape victims, victims of accidents, or victims of natural disasters. Because of the low predictive value of salient predictors of PTSD symptoms in prospective studies, such as past psychiatric history, prior trauma, and intrusive, avoidance, and hyperarousal symptoms in the immediate aftermath of the trauma (11, 12, 95), a new vulnerability model that includes pretrauma risk factors, type of trauma, and trauma responses is warranted.

A better understanding of pretraumatic risk factors would undoubtedly have important clinical implications with regard to the development of trauma-related disorders. This study supports the evidence for a strong predictive role of personality traits in the development of PTSD symptoms and comorbid psychopathological symptoms. Ideally, it would be desirable for future studies to further explore the interrelationships between possible preexisting personality factors and psychobiological mechanisms in the development of PTSD in order to integrate pre- and posttraumatic factors of vulnerability. For example, it might be speculated that a smaller hippocampus (96) somehow alters the ability for cognitive buffering against stress, resulting in both dysfunctional personality traits (e.g., low level of self-efficacy) and HPA axis alterations (e.g., low cortisol level). Alternatively, there could be multiple pathways for developing PTSD symptoms, and the course may or may not involve all of the mechanisms mentioned earlier. Accordingly, there is most likely no linear relationship between one possible risk factor and subsequent trauma-related symptoms.

Although the reported results need to be replicated to allow firm conclusions to be drawn, quantification of hostility and self-efficacy as risk or protective factors may eventually help the clinician and specific organizations to target individuals at high risk of developing trauma-related disorders (e.g., firefighters, police, military) at an early stage. One critical question that needs to be answered is whether specific psychological and biological characteristics could be used as exclusionary factors for some types of professions in order to protect individuals who wish to enter these professions. Finally, the results may indicate that coping skills training (e.g., anger/hostility management, self-efficacy training) could be helpful for primary and secondary prevention in high-risk populations.

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