Increased psychological distress among Danish gulf war veterans – without evidence for a neurotoxic background

The Danish Gulf War Study

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ABSTRACT

Introduction.: Compared with controls, up to six years after their return, Danish Gulf War veterans have a significantly higher prevalence of self-reported neuropsychological symptoms, potentially as a result of neurotoxic exposure during deployment. We tested the hypotheses that: 1) GW veterans would perform less well than controls using a computerized neuromotor test battery; and that 2) GW veterans have a psychological profile different from that of controls.

Material and methods: A cross-sectional study of 686 subjects who had been deployed in the Persian Gulf within the period August 2, 1990 until December 31, 1997; the control group comprised 231 subjects matched according to age, gender and profession. All participants underwent clinical and paraclinical examinations, along with a neuromotor test battery (CATSYS Test System®) and a psychological health status questionnaire, the SCL-90-R rating scale.

Results.: No differences were found between GW veterans and controls with respect to lifestyle and cohabitational characteristics. Differences between the two groups with respect to neuromotor function were very small. Within the GW veteran group, stratified according to clustering of neuropsychological symptoms, and stratified according to SCL-90-R score, no trends were found suggesting reduced motor function with increasing symptoms. Of nine dimensions constructed on the basis of the SCL-90-R items, six were significantly associated with being a Gulf War veteran. Statistically, the strongest associations were found for ratings of the obsessive-compulsive dimension and of the depression dimension. No associations were found with respect to phobic anxiety, paranoid ideation, and psychoticism.

Interpretation: The increased psychological distress found among Danish GW veterans seemed rather due to a mentally distressing environment than to neurotoxic exposure.

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In a cross-sectional study of Danish Gulf War (GW) veterans, a large proportion reported to suffer from neuropsychological symptoms compared with a control group matched according to age, gender, and profession (1, 2). Significant independent associations were found for: concentration or memory problems, repeated fits of headache, balance disturbances or fits of dizziness, abnormal fatigue, and problems sleeping all night (2). This clustering of neuropsychological symptoms was strongly associated with specifically strenuous conditions experienced during deployment in the Persian Gulf. Such conditions were: being shot at or other threats against oneself or colleagues, demands of high degree of concentration, dissatisfaction with the physical environment, and lack of support from immediate superiors (2).

In subsequent papers a higher prevalence was found of self-reported sexual dysfunction among male GW veterans although the biological reproductive health seemed to be unaffected compared to the controls with respect to any of the reproductive hormones measured, nor with respect to fertility or the prevalence of spontaneous abortions in the families (3, 4). These covariates of neuropsychological symptoms and sexual problems suggest a predominantly psychosocial aetiology. However, an effect on the central nervous system (CNS) of neurotoxic agents cannot be excluded, as indicated by the association of physical and chemical environmental exposures with the neuropsychological symptoms. Acute and chronic exposures to neurotoxins typically result in CNS symptoms and adversely affected neuromotoric function, with the patient additionally complaining of fatigue, irritability, confusion, depression and memory problems (5). Suggested hazardous exposures during deployment in the Persian Gulf have included a multiplicity of elements ranging from chemical or biological warfare agents, petroleum vapours, solvents, and combustion products, to pesticides, prophylactic medications and vaccines (6-8).

Moreover, a follow-up study of a subset of the population – performed by the Danish Gulf War Study in cooperation with Schools of Public Health and Medicine in Boston, USA – included a battery of neuropsychological tests and was administered to stratified, random samples of deployed veterans and control subjects. The results from this investigation found evidence of increased mood complaints related to GW service, but no significant signs of CNS dysfunction when evaluating performance across neuropsychological tasks representing domains of cognition and motor function (9).

The generic symptom questionnaire Symptom Checklist (SCL-90) has previously been used in groups with exposure to organic solvents and symptoms common in solvent induced brain dysfunction and showed clear deviations (10). To elucidate further the possible psychological effects from organic solvent exposure and stress factors the psychiatric screening tool for assessment of distress and discomfort, SCL-90-R (11), was used to test the hypothesis that 1) GW veterans have psychological distress dimensions different from those of controls. To discriminate further the possibility of a neurotoxic aetiology underlying the high prevalence of neuropsychological complaints in GW veterans we tested the hypothesis that 2) GW veterans would perform less well than controls using the neuromotor test battery CATSYS® (12) with its extensions, the TREMOR® (13) and SWAY® tests (14).

MATERIAL AND METHODS

Between January 1997 and January 1998 an epidemiological cross-sectional study was conducted, in which GW-deployed veterans were compared with a randomly selected control group of military personnel who were not deployed to the Gulf region; the control group was a priori matched according to age, gender, and profession (1). A total of 686 subjects (83.6% of the total number of deployed) and 231 controls (57.7%) participated. The health examination was voluntary and ambulant and took place at the Clinic of Occupational and Environmental Medicine, Copenhagen.

Physicians administered a standardised and by the participant previously completed questionnaire with information on occupational conditions including psychosocial, physical, chemical, and biological exposures. The participant described symptoms during the preceding 12 months of a cognitive and psychological nature. The GW veterans reported if their symptoms appeared before, during or after their deployment in the Gulf region, and the control group if their symptoms first appeared before or after August 2, 1990, ie the start of the First Gulf War. The methods have been described in detail elsewhere (1-3).

COMPUTERIZED NEUROMOTOR TEST BATTERY

As part of the clinical examination all study participants performed the CATSYS® test including its extensions, the TREMOR® test and the SWAY® test. In clinical neurological procedure of diagnostics an evaluation of the patient's coordination ability is daily routine. The coordination ability is usually estimated by qualitative methods. Such methods are sufficient for routine purposes and diagnostics, but inadequate for research purposes (15). The quantitative tests for coordination ability assessment used in this study have a high degree of clinical validity and reproducibility (15), and the test has been applied to patients with assumed toxic encephalopathy (16) and to evaluate the recovery capability of patients regarding two different anaesthetic agents (17). The CATSYS® Test System with its extensions is a computerized test system for quantifying psycho- or neuromotor performance and includes several tests (12-14):

1. Hand pronation/supination at a fixed slow (1 HZ) and a fixed fast (2.5 HZ) metronome beat.
2. Hand pronation/supination at an accelerating rhythm (from 1.6 to 7.5 HZ).
3. Finger tapping at a fixed slow (1 HZ) and a fixed fast (2.5 HZ) beat, respectively.
4. Finger tapping at an accelerating rhythm (from 1.6 HZ to 8.1 HZ).
5. Reaction time test by pressing a button to an irregularly sequential sound stimulus. All participants followed the same sequence of the above tests that lasted approximately 30 seconds.
6. Tremor test is recorded in the dominant hand by using a Tremor® Pen, which is held as an ordinary pen for 16 seconds with the arm hanging loosely and relaxed and the hand approximately 5 cm in front of the umbilicus. Through a fast-Fourier transform (FFT) analysis, the power distribution of the tremor in the frequency domain from 0.9 to 15 Hz can be determined.
7. Sway test is a postural test recorded by a balance plate, producing signals from three sensors to provide a map of the position of the force centre during the test period. This centre is defined as the centre of equilibrium of three vertical forces, recorded at the three supports of the sway plate. During the test, the subject stands erect, during two test periods with open and closed eyes, respectively, on the sway plate. The Mean Sway is calculated as the simple mean of the distance from the geometrical centre of all recorded force centre positions to each recorded force centre position. Simple mean values of transversal and sagittal sway are calculated as well.

Henceforth all results of the above test battery will be referred to as CATSYS results.

SYMPTOM CHECKLIST 90-R

As a part of the questionnaire the participants were asked to fill in The Symptom Check List, Revised Edition (SCL–90–R) henceforth referred to as SCL-90-R. The rating scale is a current, point-in-time, measurement of psychopathological dimensions, based on a 90-item self-report inventory originally developed to measure symptoms of psychological distress in medical and psychiatric patients (11). The SCL-90-R comprises nine major factors or dimensions: Somatization, obsessive-compulsive symptoms, interpersonal sensitivity, depression, anxiety, hostility, phobia, paranoid ideation and psychoticism (Appendix I). Several studies (11, 18, 19) have validated the SCL-90-R and found that it is a usable instrument for the measurement of discomfort or lack of psychological well-being. Specifically, the SCL-90-R has demonstrated its usability in examining subclinical levels of psychological disturbances in individuals having experienced severe stressful life events like war, nuclear accidents and disasters of nature. Each item of the rating scale is rated on a 5-point scale of distress, ranging from "not at all" to "extremely". The standard time set given with the questionnaire is "seven days including today".

DATA TREATMENT AND ANALYSIS

All analyses including the non-parametric Mann-Whitney rank sum test, Kendall's tau B test for trend, Spearman's rho, Chi-squared analyses, Student's t test, and the multiple logistic regression analysis (using the maximum likelihood ratio method and stepwise backward elimination), were performed using the SPSS statistical software for Windows. A two-sided probability-value of $p<0.05$ was a priori taken as statistically significant for all analyses. Non-significant results are marked NS in the tables.

In handling the SCL-90-R items several approaches were used. Each item included in the various psychological profiles based on the SCL-90-R was dichotomised, and a complaint was regarded as relevant if reported to be within the range moderate to severe (and given the value 1), and not relevant if reported to be either absent or present to a very low degree (and given the value 0). In the presentation of the so-called psychopathological profiles we present how large a proportion of GW veterans and controls, respectively, belonged to each group. Additionally we constructed an index value for each profile consisting of a summary score of all singular items included in the profile divided by number of items. Results of both approaches were in agreement, and results of the former presented in table form because of its higher degree of transparency. A corresponding philosophy was used in constructing a total SCL-90-R score. All 90 items were dichotomised and summed up. In the analysis examining the association between SCL-90-R and neuromotor function this gave the possibility of a conceptually readily understandable categorisation of participants into three groups: those without any relevant complaints, those within the range 1 to 9 complaints, and the more severe group with at least 10 relevant complaints. Finally, we calculated the General Severity Index of the SCL-90-R questionnaire in accordance with the manual, ie ad modum

Table 1. Neuropsychological, lifestyle and cohabitational, and socio-demographic characteristics of Gulf War veterans (G) and controls (C). Values presented are mean (SD) or frequency in per cent. p-value of Chi-square test (for categorical variables) or non parametric Mann-Whitney rank-sum test (for continuous variables).

	G n=686 %	C n=231 %	p
Neuropsychological symptoms within previous 12 months			
Concentration or memory problems	35.0	11.0	*
Repeated fits of headache	27.5	15.6	*
Balance disturbances or fits of dizziness	17.1	6.5	*
Abnormal fatigue (not caused by physical activity)	29.6	13.0	*
Problems sleeping all night	24.4	11.3	*
Lifestyle and cohabitational characteristics			
Low leisure time physical activity (<4 hrs/week)	51	48	NS
Current smoking	38	42	NS
Previous smoking	19	20	NS
Never smoking	42	38	NS
Alcohol use, beverages/week	17.6 (16.0)	18.7 (16.5)	NS
Regular use of hash/cannabis after August 1990	1.2	3.0	NS
Regular use of hard drugs (e.g. amphetamine, cocaine, heroin) after August 1990	0.1	1.3	NS
Regular use of sleeping medicine	2.5	0.4	**
Regular use of tranquillizing medicine	0.9	0	NS
Use of antihypertensive medicine	2.2	0.9	NS
Divorced after August 1990, %	31.3	31.0	NS
Cohabits with the same person as before August 1990, %	51.9	54.0	NS
No steady relationship including cohabitation since August 1990, %	13.7	16.1	NS
Socio-demographic factors			
Gender, male	96.9	93.1	**
Age, years	35.2 (8.9)	32.2 (8.9)	*

*) $p \leq 0.001$.
**) $p \leq 0.05$.
NS = not significant.

Derogatis (11), results of which are presented when addressing Table 4 in the results section.

ETHICS

Each participant was informed that all person data were confidential, and gave written consent about participation. The study has been approved by the Ethics Committee for Medical Research in the County of Copenhagen.

RESULTS

Table 1 shows characteristics of GW veterans and controls. As mentioned above, GW veterans had a much higher prevalence of a number of neuropsychological symptoms than controls. In contrast, no differences were found between the groups with respect to lifestyle and cohabitational characteristics. Despite the *a priori* matching according to age and gender, GW veterans were a little older than controls and comprised a slightly higher proportion of males.

Table 2 presents the results of the performance using the CATSYS. As described previously, the total test battery included a rhythmic, a reaction time, a sway and a tremor test. Differences between the two groups were very small with 23 of 26 test results being not significant, and the three results which were significant on the 0.05 level also represented small differences between the two groups.

Table 3 shows the association between CATSYS results and the neuropsychological symptoms which clustered significantly more frequently among GW veterans compared with controls; 25 of 26 test results were not significant, and the one result showing a significant trend represented only small differences between the groups.

Table 4 shows that of nine dimensions constructed on the basis of the SCL-90-R items, six were significantly associated with being a Gulf War veteran. Statistically, the strongest associations were found for ratings of the obsessive-compulsive dimension and of the depression dimension. No associations were found with respect to phobic anxiety, paranoid ideation, and psychoticism. Comparing means, using number of items on a continuous scale (using Student's t test) yielded results in accordance with those presented, ie the same factors were associated with being a GW veteran or not (not shown). In accordance with these results was also a comparison of GW veterans and controls with respect to General Severity Index. Mean values (SD) were 0.20(0.26) and 0.12(0.17), respectively, $p<0.001$ (not shown in table).

To identify which of all these dimensions were associated with being a Gulf War veteran after adjustment for the interrelationship of these factors, we performed a multiple logistic regression analysis including all nine factors (as categorical variables) together with age and gender using backward elimination of variables and the maximum likelihood ratio method (not shown). After adjustment only the obsessive-compulsive dimension was independently associated with Gulf War Veteran status; this dimension was however quite strongly correlated with the depression dimension, $r = 0.60$, $p<0.001$.

Table 2. Results of the rhythmic, reaction time, sway and tremor tests of Gulf War veterans and of controls. Values presented are means (SD). p-value of student's t test.

	Gulf War veterans n=686	Controls n=231	p
Hand supination/pronation test			
Mean (slow test), sec	–0.037 (0.070)	–0.035 (0.069)	NS
Standard deviation, sec	0.054 (0.036)	0.048 (0.034)	*
Mean (fast test), sec	–0.022 (0.031)	–0.022 (0.031)	NS
Standard deviation, sec	–0.022 (0.031)	0.026 (0.019)	NS
Max frequency, no/sec	4.9 (1.3)	4.8 (1.2)	NS
Finger tap test			
Mean (slow test), sec	–0.025 (0.046)	–0.024 (0.044)	NS
Standard deviation, sec	0.043 (0.025)	0.041 (0.024)	NS
Mean (fast test), sec	–0.020 (0.026)	–0.020 (0.026)	NS
Standard deviation, sec	0.020 (0.014)	0.019 (0.012)	NS
Max frequency, no/sec	6.1 (1.2)	6.1 (1.4)	NS
Reaction time test			
Mean, sec	0.19 (0.028)	0.19 (0.024)	NS
Standard deviation, sec	0.039 (0.025)	0.035 (0.021)	*
Sway test			
Mean (open eyes test), mm	4.62 (1.36)	4.72 (1.66)	NS
Area, mm^2	194.4 (104.5)	190.5 (105.1)	NS
Sagittal deviation, mm	3.28 (1.23)	3.24 (1.49)	NS
Transversal deviation, mm	2.55 (0.80)	2.72 (0.98)	NS
Mean sway velocity, mm/s^2	8.49 (2.36)	8.53 (2.31)	NS
Mean (closed eyes test), mm	5.90 (1.81)	5.78 (2.07)	NS
Area, mm^2	397.5 (263.3)	357.5 (222.7)	NS
Sagittal deviation, mm	3.94 (1.35)	3.88 (1.64)	NS
Transversal deviation, mm	3.57 (1.25)	3.47 (1.37)	NS
Mean sway velocity, mm/s^2	14.33 (5.60)	13.38 (4.47)	*
Tremor test			
I, m/s^2	0.14 (0.05)	0.14 (0.049)	NS
F50, Hz	7.17 (1.12)	7.24 (1.21)	NS
s(F50), Hz	2.86 (0.69)	2.87 (0.61)	NS
HI	0.86 (0.06)	0.87 (0.05)	NS

*) $p \leq 0.05$.
NS = not significant.

Table 3. Results of the rhythmic, reaction time, sway and tremor tests according to one-year prevalence of concentration or memory problems, repeated headaches, balance disturbances or fits of dizziness, abnormal fatigue, and problems sleeping all night (neuropsychological symptoms) among Gulf War veterans. Values presented are means. p-value of trend test (Spearman's rho).

	No of neuropsychological symptoms			
	0 n=259	1-2 n=265	3-5 n=143	p
Hand supination/pronation test				
Mean (slow test), sec	–0.039	–0.041	–0.030	NS
Standard deviation, sec	0.055	0.053	0.053	NS
Mean (fast test), sec	–0.024	–0.022	–0.019	NS
Standard deviation, sec	0.027	0.025	0.027	NS
Max frequency, no/sec	5.0	5.0	4.9	NS
Finger tap test				
Mean (slow test), sec	–0.025	–0.026	–0.025	NS
Standard deviation, sec	0.044	0.043	0.041	NS
Mean (fast test), sec	–0.019	–0.024	–0.018	NS
Standard deviation, sec	0.020	0.021	0.021	NS
Max frequency, no/sec	6.2	6.2	6.0	NS
Reaction time test				
Mean, sec	0.192	0.191	0.197	NS
Standard deviation, sec	0.037	0.039	0.043	*
Sway test				
Mean (open eyes test), mm	4.55	4.65	4.60	NS
Area, mm^2	183.3	203.0	192.2	NS
Sagittal deviation, mm	3.26	3.31	3.25	NS
Transversal deviation, mm	2.50	2.57	2.57	NS
Mean sway velocity, mm/s^2	8.21	8.75	8.34	NS
Mean (closed eyes test), mm	5.71	5.79	5.84	NS
Area, mm^2	373.3	402.7	408.5	NS
Sagittal deviation, mm	3.76	4.00	4.00	NS
Transversal deviation, mm	2.50	3.61	3.54	NS
Mean sway velocity, mm/s^2	14.05	14.54	13.81	NS
Tremor test				
I, m/s^2	0.136	0.146	0.143	NS
F50, Hz	7.17	7.17	7.19	NS
s(F50), Hz	2.87	2.83	2.92	NS
HI	0.86	0.86	0.87	NS

*) $p \leq 0.05$.
NS = not significant.

Table 4. Psychopathological profiles of Gulf War veterans (G), n=686, and controls (C), n=231. Kendall's tau b test for trend.

Number of items associated with the		0 %	1-2 %	3+ %	p
Somatization dimension	G	62.0	28.7	9.3	
	C	72.6	22.6	4.8	*
Obsessive-compulsive dimension	G	65.3	22.5	12.2	
	C	77.8	17.8	4.3	**
Interpersonal sensitivity dimension	G	70.1	25.4	4.6	
	C	79.5	17.5	3.1	***
Depression dimension	G	67.9	21.1	11.0	
	C	81.3	14.8	3.9	**
Anxiety dimension	G	77.7	18.1	4.2	
	C	84.0	15.2	0.9	***
Hostility dimension	G	82.2	14.0	3.8	
	C	91.3	7.4	1.3	*
Phobic anxiety dimension	G	94.4	5.1	0.4	
	C	96.1	3.9	0	NS
Paranoid ideation dimension	G	84.2	13.5	2.2	
	C	88.3	9.6	2.2	NS
Psychoticism dimension	G	83.9	14.4	1.6	
	C	87.8	10.9	1.3	NS

*) $p \leq 0.01$.
**) $p \leq 0.001$.
***) $p \leq 0.05$.
NS = not significant.

Table 5 shows the association between total SCL-90-R score categories and the results of the coordination ability, sway and tremor tests; 24 of 26 test results were not significant, and the two results showing a significant trend represented only small differences between the groups, with one result being "better" with increasing SCL-90-R score and one being "worse".

AN ADDITIONAL ANALYSIS

Finally, to validate further the usefulness of the computerized test battery, we examined the association between self-reported alcohol consumption and test performance. Table 6 shows that several of the postural tests, ie those related to swaying, were associated with alcohol consumption category, and that those who drank most had a higher tremor intensity. By contrast, their reaction time did not seem adversely affected.

DISCUSSION

The hypothesis that GW veterans would perform less well than controls using a computerized test for coordination ability, sway, and tremor was not supported. The hypothesis that GW veterans demonstrated more psychological distress (based on SCL-90-R) when compared to controls was strongly supported.

It is a well-established experience that refusals/non-responders in population-based follow-up studies are characterized by an excess psychiatric morbidity rate. According to the literature on attrition in population-based studies most frequent diagnoses in this connection are antisocial personality disorder and alcoholism (20, 21). In the present study we found a participation rate of approx. 84% of the veterans selected for the follow-up study, indicating that the main results must be regarded as representative for the entire group. The relatively lower participation rate (approx. 58%) among the not- deployed control individuals does not appear to have significant impact on the main results, since their lifestyle characteristics, drug and alcohol pattern and other background variables were not significantly different from those of the veterans except for minimal differences in use of medicine (Table 1).

The main finding of the present study is the similarity of the results of the neuromotor test battery in GW veterans and controls. A large number of tests were included and the few differences found using a rejection level of 0.05 may have been the result of stochastic variation in data alone. Earlier studies using CATSYS have shown that the test system is highly sensitive in detecting CNS effects from neurotoxic agents following acute as well as long-term exposure. Also the additional analysis performed in the present study on the association between alcohol consumption and neuromotor performance shows the ability of the system used to discriminate even subtle neuromotoric differences between groups.

Assuming a neurotoxic aetiology of neuropsychological symptoms and general psychological distress and discomfort as identified by the SCL-90-R, groups without any complaints and groups with many complaints should be expected to perform quite differently on several of the CATSYS tests. There was no such tendency. An additional finding was the strong ability of the SCL-90-R to discriminate between GW veterans and controls, with GW veterans characterised in particular by a higher proportion of subjects with obsessesive-compulsive and depressive outcomes.

Based on the above observations and the results of our study it seems unlikely that CNS symptoms in Danish GW veterans are due to neurotoxic exposure. Also in the context of history the results are credible. Research on health related problems among soldiers began during the U.S. Civil War (1861-65), when army surgeon Da Costa noted what he called "irritable heart" in troops after combat (22). Its symptoms included shortness of breath, chest pains, dizziness, rest-

Table 5. Results of the rhythmic, reaction time, sway and tremor tests according to SCL-90-R score among Gulf War veterans. Categories presented: 0=all 90 items less than moderately relevant; 1-9=1 to 9 items relevant; 10+=10 or more items relevant from a moderate to a severe degree. Values are means. p-value of trend test (Spearman's rho).

	SCL-90-R score, no of relevant items present			
	0 n=686	1-9 n=231	10+ n=96	p
Hand supination/pronation test				
Mean (slow test), sec	–0.044	–0.036	–0.036	NS
Standard deviation, sec	0.054	0.053	0.054	NS
Mean (fast test), sec	–0.028	–0.021	–0.019	*
Standard deviation, sec	0.027	0.025	0.029	NS
Max frequency, no/sec	5.0	4.9	5.0	NS
Finger tap test				
Mean (slow test), sec	–0.026	–0.025	–0.031	NS
Standard deviation, sec	0.043	0.044	0.041	NS
Mean (fast test), sec	–0.022	–0.021	–0.016	NS
Standard deviation, sec	0.021	0.020	0.021	NS
Max frequency, no/sec	6.3	6.1	6.0	*
Reaction time test				
Mean, sec	0.193	0.192	0.193	NS
Standard deviation, sec	0.039	0.038	0.041	NS
Sway test				
Mean (open eyes test), mm	4.56	4.68	4.59	NS
Area, mm^2	191.2	197.5	191.0	NS
Sagittal deviation, mm	3.24	3.35	3.25	NS
Transversal deviation, mm	2.53	2.57	2.54	NS
Mean sway velocity, mm/s^2	8.46	8.54	8.25	NS
Mean(closed eyes test),mm	5.88	5.90	5.95	NS
Area, mm^2	388.0	402.7	401.3	NS
Sagittal deviation, mm	3.91	3.92	4.13	NS
Transversal deviation, mm	3.58	3.58	3.41	NS
Mean sway velocity, mm/s^2	14.33	14.42	13.49	NS
Tremor test				
I, m/s^2	0.138	0.145	0.141	NS
F50, Hz	7.19	7.16	7.14	NS
s(F50), Hz	2.84	2.89	2.78	NS
HI	0.86	0.85	0.87	NS

*) $p \leq 0.01$.
NS=not significant.

Table 6. Results of the rhythmic, reaction time, sway and tremor tests according to level of alcohol consumption (all participants included in the analyses). Values presented are means. p-value of trend test (Spearman's rho).

	Alcohol consumption group, beverages/week			
	0 n=96	>0-21 n=438	21+ n=259	p
Hand supination/pronation test				
Mean (slow test), sec	–0.028	–0.040	–0.034	NS
Standard deviation, sec	0.050	0.053	0.052	NS
Mean (fast test), sec	–0.023	–0.022	–0.023	NS
Standard deviation, sec	0.027	0.026	0.027	NS
Max frequency, no/sec	4.9	4.6	5.0	NS
Finger tap test				
Mean (slow test), sec	–0.019	–0.024	–0.027	NS
Standard deviation, sec	0.041	0.042	0.043	NS
Mean (fast test), sec	–0.022	–0.019	–0.020	NS
Standard deviation, sec	0.020	0.019	0.021	NS
Max frequency, no/sec	6.2	6.1	6.1	NS
Reaction time test				
Mean, sec	0.20	0.19	0.19	*
Standard deviation, sec	0.040	0.039	0.036	NS
Sway test				
Mean (open eyes test), mm	4.36	4.61	4.79	*
Area, mm^2	169.2	195.4	200.9	**
Sagittal deviation, mm	3.02	3.26	3.39	**
Transversal deviation, mm	2.50	2.57	2.67	(0.06)
Mean sway velocity, mm/s^2	8.11	8.48	8.72	**
Mean(closed eyes test), mm	5.61	5.87	5.98	NS
Area, mm^2	351.4	378.6	415.2	**
Sagittal deviation, mm	3.77	3.91	4.00	NS
Transversal deviation, mm	3.36	3.56	3.59	NS
Mean sway velocity, mm/s^2	12.97	13.81	14.97	***
Tremor test				
I, m/s^2	0.140	0.133	0.159	*
F50, Hz	7.10	7.19	7.24	NS
s(F50), Hz	2.84	2.91	2.77	NS
HI	0.86	0.86	0.87	NS

*) $p \leq 0.01$.
**) $p \leq 0.05$.
***) $p \leq 0.001$.
NS=not significant.

less sleep, anger and depression. During the First World War, some doctors thought it was caused by exposure to mustard gas, until they realised soldiers who were not gassed also suffered (shell shock). Second World War and Korean War veterans called it "Battle Fatigue". The combat related phenomenon post-traumatic stress disorder (PTSD) in its current form was conceptualised after the Vietnam War. Accordingly, our findings suggest that a long-lasting physical and psychological alertness produced even in a peacekeeping and humanitarian operation with warlike exposures may result in long-term psychological discomfort, which seems to induce a complex of self-reported symptoms. Some studies, primarily from the USA, have discussed the possibility of a neurotoxic aetiology in some of the health effects found in GW veterans (23-25). It cannot be excluded that a more massive, ie relevant, exposure may have influenced those participating in the actual war operation; however, our results based on subjects deployed primarily during the post-war peace-keeping and humanitarian operation, did not support an adverse health effect of neurotoxic exposures.

One study has described post-war alcohol problems in the US-veterans of the Desert Storm (26). In the Danish Gulf War Study the reported mean consumption does not indicate any differences in alcohol (or other drug) use between veterans and controls. This finding was indirectly validated by the results of the CATSYS test showing a significant association between alcohol consumption and reduced performance with respect to sway test results – a result consistent for the open eyes and closed eyes tests.

In conclusion, the increased psychological distress found among Danish GW veterans seemed rather due to a mentally distressing environment than to neurotoxic exposure.

REFERENCES

1. Ishøy T, Guldager B, Appleyard M, Suadicani P, Hein HO, Gyntelberg F. State of health after deployment in the Persian Gulf. The Danish Gulf War Study. Dan Med Bull 1999; 5: 416-9.
2. Suadicani P, Ishøy T, Guldager B, Appleyard M, Gyntelberg F. Determinants of long-term neuropsychological symptoms. The Danish Gulf War Study. Dan Med Bull 1999; 5: 423-7.
3. Ishøy T, Andersson AM, Suadicani P, Guldager B, Appleyard M, Gyntelberg F. Major reproductive health characteristics in male Gulf War Veterans. Dan Med Bull 2001; 48: 29-32.
4. Ishøy T, Suadicani P, Andersson A-M, Guldager B, Appleyard M, Skakkebæk NE et al. Prevalence of male sexual problems in the Danish Gulf War Study. Scand J Sexol 2001; 4: 41-53.
5. Baker EL, White RF, Murawaski BJ. Clinical evaluation of neurobehavioral effects of occupational exposure to organic solvents and lead. Int J Med Health 1985; 14: 135-58.
6. Proctor SP, Heeren T, White RF, Wolfe J, Borgos MS, Davus JD. Health status of Persian Gulf War veterans: self-reported symptoms, environmental exposures and the effect of stress. Int J Epidem 1998; 27: 1000-10.
7. Ishøy T, Suadicani P, Guldager B, Appleyard M, Gyntelberg F. Risk factors for gastrointestinal symptoms. The Danish Gulf War Study. Dan Med Bul 1999; 5: 420-23.
8. Haley RW, Kurt TL. Self reported exposure to neurotoxic chemical combinations in the Gulf War. JAMA 1997; 277: 231-7.
9. Proctor S, White R, Heeren T, Debes F, Glørfelt-Tarp B, Appleyard M et al. Cognitive function in Danish Gulf War Veterans. Journal of Psychopathology and Behavioural Assessment (in press).
10. Karlsson B, Osterberg K, Orbaek P. Euroquest: the validity of a new symptom questionnaire. Neurotoxicology 2000; 21: 783-9.
11. SCL-90-R® Administration, Scoring and Procedures Manual II for the Revised Version. Leonard R. Derogatis. Clinical Psychometric Research, Inc.
12. Danish Product Development Ltd. CATSYS 6.0 user's manual. Snekkersten, Denmark, 1994.
13. Danish Product Development Ltd. TREMOR 3.0 user's manual. Snekkersten, Denmark, 1994.
14. Danish Product Development Ltd. SWAY 7.0 user's manual. Snekkersten, Denmark, 1994.
15. Gyntelberg F, Flarup M, Mikkelsen S, Palm T, Ryom C, Suadicani P. Computerized coordination ability testing. Acta Neurol Scand 1990; 82: 39-42.
16. Mikkelsen S, Jørgensen M, Browne E, Gyldensted K. Mixed solvent exposure and brain damage. A study of painters. Acta Neurol Scan 1988; 78: (suppl 118): 1-143.
17. Ryom C, Flarup M, Suadicani P, Palm T, Mikkelsen S, Gyntelberg F. Recovery following thiopentone or propofol anaesthesia assessed by computerized coordination measurements. Acta Anaesthesiol Scand 1992; 36: 540-5.
18. Wilson JH, Taylor PJ, Robertson G. The validity of SCL-90 in a sample of British men remanded to prison for psychiatric reports. Br J Psychiatry 1985; 147: 400-3.
19. Baum A, Gatchel RJ, Schaeffer MA. Emotional, behavioural and physiological effects of chronic stress at Three Mile Island. J Cons Clin Psychology 1983; 51: 565-72.
20. Eaton WW, Anthony JC, Tepper S, Dryman A. Psychopathology and attrition in the epidemiological catchment area surveys. Am J Epidemiol 1992; 135: 1051-9.
21. Badawi MA, Eaton WW, Myllyluoma J, Weimer LG, Gallo J. Psychopatholgy and attrition in the Baltimore ECA 15-year follow-up 1981-1996. Soc Psychiatr Epidemiol 1999; 34: 91-8.
22. Da Costa JM. On irritable heart: a clinical study of a form of functional cardiac disorder and its consequences. Am J Med Sci. 1871; 61: 17-52.
23. Gray GC, Reed RJ, Kaiser KS, Smith TC, Gastanaga VM: Self-reported symptoms and medical conditions among 11,868 Gulf War-era veterans: the Seabee Health Study. Am J Epidemiol 2002; 155: 1033-44.
24. Wolfe J, Proctor SP, Erickson DJ, Hu H. Risk factors for multisymptom illness in US Army veterans of the Gulf War. J Occup Environ Med 2002; 44: 271-81.
25. White RF, Proctor SP, Heeren T, Wolfe J, Krengel M, Vasterling J et al. Neuropsychological function in Gulf War veterans: relationship to self-reported toxicant exposures. Am J Ind Med 2001; 40: 42-54.
26. The Iowa Persian Gulf Study Group. Self-reported Illness and Health Status among Gulf War Veterans. JAMA 1997; 277: 238-5.

APPENDIX I

DEFINITION OF PSYCHOPATHOLOGICAL PROFILES

The SCL-90-R rating Scale

Nine psychopathological status groups were defined based on the SCL-90-R questionnaire.

Somatization profile

Somatization reflects distress arising from perceived bodily dysfunctions. Complaints are focused on conversion or pseudoneurologial symptoms, cardiovascular, gastrointestinal, and the respiratory system. Other systems with strong autonomic mediation are also represented in this dimension. Headaches, pain and discomfort of the gross musculature are also components of the definition. These symptoms and signs have all been demonstrated to have a high prevalence in disorders demonstrated to have a functional aetiology, although all may be reflections of true physical disease.

Obsessive-compulsive profile

The obsessive-compulsive dimension is as somatization regarded as an anxiety-based disorder. The obsessive-compulsive individuals have thoughts, impulses and actions that are experienced as unremitting and irresistible, but are of an ego-alien or unwanted nature.

Interpersonal sensitivity profile

This dimension reflects feelings of personal inadequacy and inferiority, particularly in comparisons with others. Discomfort during interpersonal interactions is characteristic manifestations.

Depression profile

The depression dimension of SCL-90-R reflects a broad range of manifestations of clinical depression. Ranging from mood disturbances, sadness and dejection to signs of withdrawal of life interest, lack of motivation, and reduced vital energy are symptoms in the depression dimension.

Anxiety profile

This dimension is composed of a set of symptoms and signs that are associated clinically with a high level of manifest anxiety. The dominant characteristic is a free-floating generalised anxiety. The inner experience is that the threat or subject of the fear is omnipresent hovering about unattached to anything specific. General signs such as nervousness, tensions and trembling are included in the definition, as are panic attacks and feelings of terror.

Hostility profile

The hostility dimension reflects thoughts, feelings and actions, that are the negative affects of the state of anger. The symptoms are often impulsive, but incomprehensible for the individual and therefore painful. The selection of items includes all three modes of manifestation and reflects aggression, irritability, rage and resentment.

Phobic anxiety profile

Phobic anxiety is defined as a persistent and irrational fear of people, places, objects or situations, and it is characterised as being disproportionate to the stimulus. It results in a compelling desire to avoid the dreaded object or situation. The items of the present dimension focus on the more pathonomic and disruptive manifestations of phobic behaviour.

Paranoid ideation profile

This dimension represents paranoid behaviour fundamentally as a disordered mode of thinking. The cardinal characteristics of projective thought, hostility, suspiciousness, grandiosity, fear of loss of autonomy, and delusions are viewed as primary reflections of this disorder, and item selection is orientated toward representing that conceptualisation.

Psychoticism profile

The psychoticism scale was developed to represent the construct as a continuous dimension of human experience. Items indicative of a withdrawn, isolated schizoid life style were included, as were first-rank symptoms of schizophrenia, such as hallucinations and thought-broadcasting. The psychoticism scale provides a graduated continuum from mild interpersonal alienation to dramatic evidence of psychosis.