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MILD VERSUS SEVERE FATIGUE IN POLIO SURVIVORS: SPECIAL CHARACTERISTICS

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In studies conducted on polio survivors with late effects of poliomyelitis, new fatigue is frequently reported. The main purpose of the present study was to examine the characteristics of polio survivors reporting severe fatigue versus those reporting mild or no fatigue. From a survey among 276 representative Norwegian polio survivors, we recruited all patients with mild/no fatigue and those with severe fatigue, without other diseases than poliomyelitis. Out of 276 polio survivors, 43 reported mild, 113 moderate and 118 severe fatigue (2 were missing). Only 12 with mild fatigue, 21 with moderate and 14 with severe fatigue had no other diseases and health problems related to fatigue. Six of these patients with mild/no and 9 with severe fatigue, and 16 healthy persons participated in the study. The subjects were assessed with the Fatigue Questionnaire, Fatigue Severity Scale, Visual Analog Scale for pain and fatigue, SCL-90-R, cognitive tests, event-related brain potentials (ERPs), blood and urine parameters, spirometry, exercise and muscle strength tests, 24-hour pulse registration, Sunnaas ADL-index and the Rivermead Mobility Index. The group with severe fatigue had significantly more elevated scores on SCL-90-R, measuring obsessive-compulsive behaviour, depression and anxiety than both the mild fatigue group and the controls. They also had higher scores on the somatization scale than the control group. No other test results showed significant differences between the mild/no and the severe fatigue polio groups. The present results give no support to the hypothesis of "brain fatigue in polio survivors, assessed by cognitive tests or ERPs. Moreover, the physical test results did not correspond to perceived fatigue. Thus, the only characteristics distinguishing polio survivors with severe fatigue from those with mild/no fatigue in this study were psychological characteristics. However, a larger group of polio survivors suffer from additional diseases, and such diseases should be ruled out during a comprehensive rehabilitation program.

Key words: fatigue, poliomyelitis, rehabilitation, post-polio syndrome.

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INTRODUCTION

In studies conducted on persons with late effects of poliomyelitis, new fatigue is frequently reported (34–91%) (1). Several pharmacological studies using medications such as amantadine, prednisone, human growth hormone, bromocriptine and pyridostigmine have been conducted in order to reduce fatigue in persons diagnosed with the so-called post-polio syndrome (PPS) (2), but the effect is so far not convincing (3).

Bruno et al. (4) claim that polio survivors differentiate between physical tiredness, associated with new muscle weakness and decreased physical endurance, and "brain fatigue" or mental fatigue, characterized by problems with attention and concentration. Studies assessing cognitive functions with neuropsychological tests in this group are few and have given divergent results (5–7).

Research has been conducted on concentration and memory deficits in patients with fibromyalgia syndrome (8), and on patients with chronic fatigue syndrome (9, 10).

The recording of cognitive event-related brain potentials (ERP) during an active auditory oddball discrimination task is a method for studying cerebral information processing. The P3 component of the ERP has been extensively studied and is regarded as a valid measure of attention, stimulus evaluation and memory updating (11). A limited number of studies have incorporated ERP measures when studying the neuropsychological or neurophysiological features of fatigue. In patients with chronic fatigue syndrome (CFS) ERP studies have offered diverging results. To our knowledge no studies have employed the ERP method in exploring a possible neurogenic origin of post-polio fatigue.

Bruno and colleagues have suggested that there is a common pathophysiology between post-polio fatigue and chronic fatigue syndrome (12). Further, they hypothesize that mental post-polio fatigue is caused by poliovirus-induced damage to the neurons of the reticular activation system (RAS), referring to post-mortem histopathology from nearly 50 years ago where brain stem centers were found to be "involved in even mild cases" of polio (4, 13). In a more recent MRI study hyperintensive signals in the reticular formation, putamen, medial leminiscus or white matter tracts were found in eight out of 15 polio survivors who reported severe fatigue, but not in any of the subjects who reported no or little fatigue (4).

The present study is based on our recent survey among 276 Norwegian polio survivors, representative of the general

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population of polio survivors in Norway (14), where among other measures the Fatigue Questionnaire (15) and the Fatigue Severity Scale (16) were included. Comparison was made to a recently published study on fatigue in the Norwegian population (17).

The main finding in our previous study was that the incidence of fatigue among polio survivors was considerably higher than in the normative data (14). Secondly, our study showed that physical fatigue represented the major problem for polio survivors. Thus, the study did not give great support to the hypothesis of "brain fatigue". Thirdly, the polio survivors in our recent study had significantly more diseases and health problems besides their polio than the normative group. When we analyzed the correlations between subject characteristics and reported fatigue, the highest correlation was found between other health problems and fatigue. However, a significantly higher percentage of subjects who were affected in the respiratory muscles reported severe fatigue, i.e. to be tired all day for more than 6 months (14).

Finally, fatigue in our former study of polio survivors was not related to age. In contrast, in the normative data, the highest total fatigue scores were found among the oldest, for both genders (14, 17).

The primary aim of the present study was to compare characteristics in the "extreme fatigue groups" by performing objective measurements probably related to fatigue in these subjects. Thus, we studied post-polio subjects who reported severe fatigue and post-polio subjects who reported mild/no fatigue, respectively. Our final aim of this study was to draw implications from the results with relevance for clinical counselling of polio survivors.

MATERIAL AND METHODS

Material and data collection

In our previous survey, performed during May to June 1999 (14), we trichotomized polio survivors according to scores on the Fatigue Severity Scale (FSS). The three groups were defined in relation to standard deviation (SD) from mean in the normative data (16). Forty-three persons (16% of the population) were classified as mildly fatigued (0–2 SD from mean), 113 patients (41%) as moderately fatigued (3–5 SD from mean) and 118 patients (41%) as severely fatigued (>5 SD from mean). (Data were missing on the FSS for two persons.) We focused specifically on patients with no other diseases and health problems related to fatigue. Twelve patients (28%) in the mild fatigue group, 21 patients (19%) in the moderately fatigued group and 14 (12%) in the severely fatigued group had no other diseases or health problems.

In April 2000 we asked all respondents from the latter mild and the severe fatigue groups to participate in a follow-up study, totally 26 persons. Two patients were now medically unfit, 6 patients did not want to participate in the study, while three patients reported moderate fatigue with repeated testing, instead of mild or severe fatigue, and were therefore excluded. Thus, the present study included 15 patients, six with mild and nine with severe fatigue. The participants attended an outpatient clinic for 2 days, first in April or May 2000 and thereafter in the period June–August 2000. The control group consisted of 16 healthy employees or earlier employees in our hospital and were selected to be comparable with respect to sex, age and education. Demographic characteristics are shown in Table I.

Table I. *Demographic characteristics of the polio and the control group*

	Polio survivors ($n = 15$)	Controls ($n = 16$)
Sex (female/male)	12/3	13/3
Age		
Mean (SD)	56.8 (8.4)	55.3 (8.5)
Range	34–73	38–75
Years of education		
Mean (SD)	12.0 (4.0)	12.6 (3.9)
Range	7–19	8–19

Measurements

Sociodemographic items. The survey included items on age, gender, marital status, occupational status, education, age at polio onset and years since polio onset.

Health variables. The former survey (14) included items on past and current diseases (hypertension, myocardial infarction, heart failure, cancer and diabetes) and current health problems (chronic allergy, arthritis, low back pain, visual impairment, chronic skin problems, chronic lung problems, deafness or hearing problems, and other health problems). In this study, only persons who reported no diseases or current health problems were included.

Fatigue Questionnaire (FQ) is intended for the detection of fatigue cases in epidemiological studies (15). The FQ asks for fatigue symptoms experienced during the last months compared with how subjects felt when last feeling well. The responses are "less than usual", "same as usual/not more than usual", "more than usual" and "much more than usual". The 11 items measure both physical and mental features of fatigue. Additionally, two items ask for the duration and extent of fatigue. According to the Norwegian normative study by Loge et al. (17), the responses are scored on both Likert (0, 1, 2, 3) and dichotomized (0, 0, 1, 1) scales, the latter meaning that only fatigue "more than usual" and "much more than usual" are given scores. Based on the results from the validation study, "substantial fatigue" was defined by total dichotomized scores of ≥ 4, and fatigue "caseness" was defined by total dichotomized scores of ≥ 4 and a duration of >6 months. The FQ measures Total Fatigue (TF, all items, maximum score 33), with the two underlying constructs Physical Fatigue (PF, seven items, maximum score 21) and Mental Fatigue (MF, four items, maximum score 12).

Fatigue Severity Scale (FSS) was originally designed to measure fatigue experienced by persons with sclerosis multiplex (16) including a list of nine statements assessing perceived fatigue. Each statement (e.g. " I am easily fatigued") is rated on a scale from 1 = "strong disagreement" to 7 = "strong agreement". The individual score is the mean of the numerical responses to the nine statements, i.e. a maximum score of 7 can be achieved.

Visual Analog Scale for estimation of pain (0–100 millimeter). The respondent is asked to estimate pain last week, from 0 = no pain to 100 = unbearable pain.

Visual Analog Scale for estimation of fatigue (0–100 millimeter). The respondent is asked to estimate fatigue last week, from 0 = no fatigue to 100 = unbearable fatigue.

Symptom Check List-90 items, Revised (18, 19). SCL-90-R is a widely used instrument of self-reported psychological distress and psychopathology based of the core items on the Hopkins Symptom Checklist. The instrument comprises nine sub-scales, as well as a global symptom index. The respondent is asked to rate each item on a 5 point scale varying from 0 = "not at all" to 4 = "very much".

Neuropsychological tests. The Hiscock Digit-Memory Test, 5 seconds condition where number of correct responses on easy and difficult tasks

Table II. *Characteristics of polio respondents with mild* (n = *6) and severe* (n = *9) self-reported fatigue*

	Mild fatigue ($n = 6$)	Severe fatigue ($n = 9$)
Age (years), mean (SD)	60 (7)	54 (9)
range	55–73	34–64
Age polio onset (years), mean (SD)	6 (4)	8 (6)
range	1–12	1–15
Years since polio onset, mean (SD)	54 (6)	46 (5)*
Female/male (*n*)	4/2	8/1
Marital status (*n*)		
Single	3	1
Married/cohabitant	2	5
Separated/divorced	1	2
Widow/widower	–	1
Educational status (*n*)		
Second level, first stage (lower)	3	4
Second level, second stage (medium)	2	–
Third level (university)	1	5
Work/source of income (*n*)		
Paying job	4	1
Disablement benefit	1	7
Old-age pension	1	1
Body parts affected by polio (*n*)		
Upper extremities	2	3
Lower extremities	5	8
Back and abdomen	2	4
Respiratory muscles	–	2

[1] Student's *t*-test or χ^2, ns = $p > 0.05$.
* $p = 0.03$.

and reaction time are registered: validity test (20); Grooved Pegboard: fine motor coordination (21); Symbol Digit Modalities Test, Oral and Written administration: psychomotor speed and cerebral efficiency (21); from Wechsler Adult Intelligence Scale (WAIS) (21), Digit Span: short-term memory; Similarities: verbal abstraction; Block Design: visuo-construction; Tactual Performance Test Children's version: tactual perceptual skills; Paced Auditory Serial Addition Test, inter-number intervals 4 and 3 seconds: working memory, divided attention (21); Stroop: inhibition (22) and CERAD: learning, recall and recognition (23).

Event-related potentials. The ERP paradigm was designed as a three-stimulus auditory oddball discrimination task. A total of 360 tones were presented through earphones. Standard stimuli (78%) consisted of 80 dB, 1000 Hz tones of 75 ms duration; target stimuli (14%) deviated from standard tones by duration only (25 ms), whereas distractor stimuli (14%) were noise of 90 dB, 1500 Hz, 100 ms duration. Inter-stimulus interval was set to 1500 ms, and stimuli were presented in a random sequence. Subjects were instructed to press a response button whenever the target stimuli appeared. Continuous EEG activity was recorded from 19 electrodes (Ag/AgCl) placed in accordance with the international 10–20 system (24). Data were sampled at 500 Hz A/D rate with a 0.05 Hz high pass and 70 Hz low pass filter. EEG signals were amplified by a SynAmp DC amplifier. Recordings were epoched into 1100 ms segments, corrected for eye movement artifacts, and epochs with amplitudes exceeding $\pm 100\ \mu V$ were rejected. Averaging was performed separately for standard, target and distractor stimuli. Only post-polio subjects participated in the ERP study. The control subjects did not participate in the testing.

Blood parameters. All subjects were examined by the following blood and urine variables to rule out other medical conditions potentially related to fatigue (25): full blood count, erthrocyte sedimentation rate, alanine aminotransferase, total protein, albumin, globulin, alkaline phosphatase, calcium, phosphate, glucose, urea, electrolytes, creatinine, thyroid stimulating hormone, and urin analysis. The analysis was performed according to the routine methods at the Clinical Chemical Laboratory, Sunnaas Rehabilitation Hospital.

Physiological measures. Spirometry was performed by dry spirometry (SensorMedics Vmax 229D, SensorMedics Corporation, California, USA). The measured forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) and maximal voluntary ventilation (MVV) were compared with predicted values for sex, height and age in healthy persons [European updated predicted values, European Respiratory Society, SensorMedics].

Exercise testing was performed either with arm ($n = 2$) or leg ($n = 11$) bicycle ergometer (Ergo-line Ergometrics 800 S, Ergo-line, Bitz, Germany and Siemens Ergomed 840, Siemens, Erlangen, Germany). The maximal oxygen uptake (VO_{2max}) test was performed with a starting workload below the lactate threshold, and with an increase in workload from 5–15 Watts every minute until exhaustion. The velocity rate was between 70 and 80 rpm.

During the test, the oxygen uptake (VO_2), ventilation (V), respiratory exchange ratio and heart rate (HR) were recorded. Oxygen uptake was measured breath by breath, with an averaging interval of 30 seconds. Peak VO_2 was designated VO_{2max} even if some subjects did not reach the criteria for VO_{2max} (26). VO_{2max} was compared with predicted average values for age and sex in healthy persons (27). Predicted VO_{2max} with arm ergometry was presumed to be 70% of predicted VO_{2max} with leg ergometry (26).

At the end of the maximal exercise test, the blood pressure was measured, the subjects rated their subjective perceived exertion according to the Borg scale (28), and the reason for discontinuing the test was registered. Three minutes after discontinuing the test, the maximal blood lactate was measured capillary from a fingertip (YSI 1500 Sport Lactatanalyzer, YSI Incorporated, Ohio, USA).

Muscle strength was performed clinically by an experienced physiotherapist, in 32 muscle groups (Oxford Scale 0–5, total range in all muscles 0–160).

24-hour pulse registration were performed in all subjects using a Polar Pulsewatch (Polar, Finland). The participants filled out a form of registration of activities during 24 hours and perceived exertion during these activities using the Borg scale. As an expression of a high degree of physical stress, the time when the person had a pulse rate higher than 60% of the Heart Rate Reserve (HRR) was recorded (26).

Sunnaas ADL Index (29) is an index covering ADL activities developed in Sunnaas Rehabilitation Hospital. The scale has 12 activity-areas with scores ranging from 0–3 on each, the maximum score being 36. The scores O and 1 indicate that the person is not independent, whereas 2 and 3 indicate independency of help from other persons in ADL.

Rivermead Mobility Index (30) is an index ranging from 1–15 covering mobility functions such as turning around in bed without help, standing, climbing stairs, and running 10 meters.

Statistical analysis

Results are presented with mean and standard deviations, or median and range. Differences between groups were analyzed using one-way ANOVA with post-hoc Bonferroni group comparisons, or χ^2 analyses for categorical data. Bivariate Pearson's correlation was applied to analyse how measures of fatigue related to neuropsychological, electrophysiological and psychiatric variables. Due to the great number of parameters, there is a possibility of chance findings. Therefore, we only emphasize results with low *p* values. All statistical analyses were performed using the SPSS for windows, version 10.0. The study was approved by the Regional Committee for Medical Ethics in Norway.

RESULTS

Characteristics of the mild and the severe fatigue polio groups are presented in Table II. In the mild fatigue group average years

Table III. *Mean (SD) of the Fatigue Severity Scale (FSS), Fatigue Questionnaire (FQ), Visual Analog Scales (VAS) for pain and fatigue, results of SCL-90-R and mean neuropsychological test results (T-scores) in polio survivors with mild fatigue (MF), severe fatigue (SF), and healthy controls (Con). Higher scores indicate more fatigue and psychopathology, lower T-scores indicate reduced performances*

	Mild fatigue ($n = 6$)	Severe fatigue ($n = 9$)	Controls ($n = 16$)	F[1]	*p*-value	Post-hoc analysis[2]
FSS (1–7)	2.6 (1.0)	6.5 (0.4)	3.3 (1.2)	37.53	<0.001	SF > MF, SF > Con
FQ total fatigue (0–33)	10.0 (2.5)	15.2 (4.3)	11.9 (2.4)	5.64	<0.001	SF > MF
FQ physical fatigue (0–21)	6.8 (1.3)	10.2 (3.1)	7.7 (1.8)	5.45	0.01	SF > MF, SF > Con
FQ mental fatigue (0–12)	3.2 (1.6)	5.0 (1.3)	4.3 (1.0)	4.05	0.03	SF > MF
FQ caseness (yes/no)	0/6	2/7	2/14	1.59[3]	NS	
VAS pain (0–100)	16.0	18.0	5.6	3.43	0.05	
VAS fatigue (0–100)	9	44	17.5	6.92	0.004	SF > MF, SF > Con
SCL-90-R (T-scores)						
Somatization	52	60	47	10.40	<0.001	SF > Con
Obsessive–compulsive	47	64	51	6.61	0.004	SF > MF, SF > Con
Interpersonal sensitivity	48	55	50	4.34	0.023	SF > MF
Depression	47	67	50	9.49	0.001	SF > MF, SF > Con
Anxiety	46	57	48	6.95	0.004	SF > MF, SF > Con
Hostility	48	57	51	1.18	NS	
Phobic anxiety	45	63	48	1.96	NS	
Paranoid ideation	46	50	51	0.69	NS	
Psychoticism	47	53	50	0.72	NS	
Global Severity Index	47	62	49	8.42	0.001	SF > MF, SF > Con
Caseness yes/no	0/6	4/5	1/15	7.64[3]	0.02	
Neuropsychological tests (T-scores)						
Motor coordination (best hand)	53	45	51	1.01	NS	
Tactual perceptual skills (seconds)	127	107	159	1.44	NS	
Tact. percept. recall: figures (0–6)	3.7	4.2	4.7	1.33	NS	
Tact. percept. recall: spatial (0–6)	2.7	3.1	3.8	0.92	NS	
Psychomotor speed, written	54	47	53	1.99	NS	
Psychomotor speed, oral	58	49	55	2.53	NS	
Divided attention 4 seconds (% error)	23	15	9	7.29	0.003	MF > Con, MF > SF
Divided attention 3 seconds (% error)	43	20	19	0.09	NS	
Verbal learning	55	58	54	0.59	NS	
Verbal recall	55	55	56	0.04	NS	
Verbal recognition Yes	55	53	51	0.68	NS	
Verbal recognition No	47	54	54	3.20	NS	
Verbal abstraction (scaled score)	12	15	13	2.48	NS	
Visuoconstruction (scaled score)	13	12	12	0.33	NS	
Short-term memory (scaled score)	10	9	10	0.35	NS	
Response inhibition (Stroop C-W)	37	44	47	1.94	NS	

[1] One-way ANOVA, [2] Bonferroni post-hoc analysis, [3] Chi-square, NS = non significant.

since polio onset were significantly higher than in the severe fatigue group, and the mild fatigue group was slightly older (NS) than the severe fatigue group.

Table III shows the fatigue scores for the three different groups. The severe fatigue group reported significantly more fatigue on all measures than the mild fatigue group. Also, the differences between the severe fatigue group and the controls were significant on the Fatigue Severity Scale, the Mental Fatigue subscale on Fatigue Questionnaire and the Visual Analog Fatigue Scale. The groups did not differ significantly on the Visual Analog Scale assessing pain. The mean fatigue scores for the control group were similar to the normative data. When comparing the repeated assessments of fatigue in the polio patients (the present versus the survey study) the mean values showed no significant differences. Table III also shows the results from the SCL-90-R rating. The severe fatigue group reported significantly more obsessive-compulsive behaviour, depression and anxiety than both the mild fatigue group and the controls, and also more somatization than the controls.

We asked for sleep disorders and the use of hypnotica. Also, the SCL-90-R contains two questions on sleep; problems with falling asleep and disturbed/uneasy sleep (items 44 and 66, respectively). The severe fatigue group reported significantly more sleep disorders (89%) than the mild fatigue (33%) and the control group (25%) ($\chi^2 = 14.5$, $p = 0.006$), but the use of hypnotica did not reach a significant difference between the groups (22%, 17%, 6%, $\chi^2 = 1.40$, NS). The severe fatigue group had significantly more problems with falling asleep (mean values 2.2, 0.5, 0.9, F = 5.65, $p = 0.009$), but not with disturbed/uneasy sleep (mean values 1.9, 0.7, 0.9, F = 2.51, NS).

Table III also shows the neuropsychological results. Only divided attention on the easiest conditions (4 seconds) differed between the groups, the mild fatigue group showing more impairment than the severe fatigue group and the controls. As to

Table IV. *Values of pulmonary function, maximal leg or arm ergometry test, strength test, Sunnaas ADL-Index, and Rivermead Mobility Index of the mild and severe polio groups, respectively. Values are means (SD), except that median and range are reported for muscle strength. FVC = forced vital capacity, FEV_1 = forced expiratory volume in one second, MVV = maximal voluntary ventilation, VO_2 = oxygen uptake. Subjective perceived exertion at max VO_2: Borg scale (6–20). Strength test performed clinically by Oxford Scale (0–5): Upper extremities = 16 muscle groups, lower extremities = 14 muscle groups, back and abdomen = 2 muscle groups. Total = 32 muscle groups. For Sunnaas ADL-Index and Rivermead Mobility Index; higher scores indicate higher function*

	Mild fatigue ($n = 6$)	Severe fatigue ($n = 9$)	p value[1]
Lung functions			
FVC (% pred)	110.7 (20.4)	106.6 (28.3)	NS
FEV_1 (% pred)	97.8 (25.8)	97.8 (20.9)	NS
FEV_1/FVC (%)	71.8 (7.9)	79.3 (9.9)	NS
MVV (% pred)	119.7 (38.3)	100.1 (28.0)	NS
Maximal exercise capacity[2]			
VO_2 (ml/kg/min)	17.8 (5.3)	14.6 (3.1)	NS
VO_2 (% pred)	48.4 (10.3)	53.8 (15.3)	NS
Perceived exertion at max VO_2			
Borg Scale (6–20)	17.8 (1.1)	19.5 (1.2)	0.04
Strength test (Oxford Scale)			
Upper extremities (0–80)	80 (37–80)	67 (31–80)	NS
Lower extremities (0–70)	36 (10–64)	54 (20–64)	NS
Back and abdomen (0–10)	7.5 (7–8)	8 (3–10)	NS
Total (0–160)	105 (97–135)	130 (66–154)	
Sunnaas ADL-Index (0–36)	32.5 (3.6)	32.8 (2.8)	NS
Rivermead Mobility Index (0–15)	12.2 (2.8)	13.2 (2.8)	NS

[1] Student's t-test [2] 4 patients missing, 2 patients could not be tested due to pareses and 2 patients due to elevated blood pressure.

the validity test (Victoria) there were no significant differences on neither the easy nor the hard condition tasks, but reaction time for responding was significantly slower in the severe fatigue group compared to the control group ($p = 0.008$), but not compared with the mild fatigue group.

Amplitudes and latencies for the cognitive ERP components N2 and P3 from the midline electrodes (Fz, Cz, Pz) were analyzed for both target and distractor tones. There were no significant differences between the mild and severe fatigue polio groups in any of these ERP parameters. Moreover, there were no significant correlations between these ERP parameters and fatigue as measured by the Fatigue Severity Scale, Fatigue Questionnaire or the Visual Analog Fatigue Scale.

Table IV summarizes the results from the lung function tests, the maximal exercise test, the strength tests, Sunnaas ADL-index and Rivermead Mobility Index. Lung functions were within normal values with no differences between the two groups. Neither, no significant differences in maximal oxygen uptake, clinical muscle strength tests, Sunnaas ADL and the Rivermead Mobility Index were found between the groups.

In the 24-hour pulse registration, average pulse frequency in the severe fatigue and in the mild fatigue group was equal during both day- and night-time. Furthermore, no significant difference in the time with pulse frequency above 60% of Heart Rate Reserve.

The two groups used a similar amount of mobility devices. In the severe fatigue group six persons walked without devices indoor, two persons used orthopedic devices and one used a combination of orthopedic devices and electric wheelchair. In the mild fatigue group, two patients used no devices for walking indoor, three used orthopedic devices and one manual wheelchair. In outdoor mobility, five persons in the severe fatigue group used no devices, three used orthopedic devices and one used an electric wheelchair. In the mild fatigue group, two patients used no devices, two used orthopedic devices and two used a combination of orthopedic devices and manual/electric wheelchair.

Blood and urine results were within normal values for all measured parameters in all subjects, indicating no other diseases that could explain the fatigue.

DISCUSSION

The present study showed very few significant differences between the severe and the mild fatigue group of polio survivors and the controls. The only differences were that the severe fatigue group had fewer years since onset of polio and showed more psychopathology than the mild fatigue group (Tables II and III). The SCL-90-R showed that the severe fatigue group had elevated scores on the sub-scales obsessive-compulsive behaviour, depression and anxiety compared with the mild fatigue group (Table III), obsessive-compulsive items in these cases reflecting cognitive inefficiency and compensatory behaviour. Only one cognitive test of divided attention distinguished the two groups, showing lower performances in the mild fatigue group. No other significant differences were found between the two groups on the measured parameters. These results indicate that fatigue in polio survivors is no specific sign of polio itself. Our previous study showed that most polio survivors had additional diseases that mainly can explain the fatigue (14). The present findings in the PPS patient group could be comparable

with findings in other patients groups with other chronic diseases, but studies focusing on fatigue are very few.

Hazendonk & Crowe (7) reported that polio survivors with PPS, in comparison with healthy controls and polio survivors without PPS, were more depressed, reported a higher frequency and severity of overall symptoms, had a stronger belief that they suffered from a physical illness, reported more feelings of anger and interpersonal conflicts, and had a higher level of hypochondria. These authors stated that there is a next challenge to researchers to determine the exact nature and direction of the relation between PPS and depression. Tate et al. (31) showed that distressed/depressed subjects reported increased pain, rated that their health was worse, and they were less satisfied with life than those without these symptoms. In another study Schanke found (32) a significant correlation between self-reported fatigue and depression and anxiety. In a study by Kemp et al. (33) the prevalence of depressive disorders was not significantly different between polio survivors and age-matched controls, although the post-polio group tended to have more symptomatology and an overall depressive disorder prevalence of 28%. The authors found it to be of special concern that treatment of any kind for persons with polio having probable or confirmed depressive disorders seemed non-existent. In a study by Schanke et al. (34) those who reported that they had been psychologically harmed by the treatment received at the time they contracted polio used significantly more medication, and reported more pain, general fatigue, psychological distress, sleep disturbances and concentration problems. Thus, several studies document the relationship between psychological distress and fatigue in polio survivors. The results of the present study, also indicate that psychological distress, depression and anxiety are correlated to fatigue in polio survivors.

We found that 89% of the severe fatigue group reported sleep disorders compared to 33% and 25% of the mild fatigue and the control group, respectively. In a study by van Kralingen et al. (35) almost one-half of the post-polio patients reported complaints of sleep disorders likely to influence daytime functioning. Sleep disorders may have various causes such as depression, emotional distress, hypoventilation, pain or other diseases.

With regard to the neuropsychological results, we found only one significant difference, as the mild fatigue group, not the severe as expected, showed lower performances on the easiest condition on the divided attention test (Table III). Other studies show divergent results. In one study by Bruno et al. (5) three PPS patients with mild or no fatigue were compared with three patients with severe fatigue. None of the patients reported depression. The fatigued patients performed worse, and Bruno and colleagues suggested that the PPS patients suffered from an "attentional deficit". In a recent study Bruno & Zimmerman (36) concluded that the results support the hypothesis that decreased dopamine secretion, possibly secondary to poliovirus damage to the basal ganglia, may underlie not only fatigue and impaired attention, but also word finding difficulties in polio survivors. A lack of problems with attention, memory and concentration in polio survivors were, however, found in a recent study by Hazendonk & Crowe (7). In a study by Freidenberg et al. (6), testing polio survivors with and without progressive weakness, pain and fatigue, the hypothesis of "brain fatigue" was not supported, and the performance on tests of attention was significantly lower in the subjects who had no symptoms. Grafman et al. (37) refer to an unpublished study of his own where post-polio patients demonstrated slower response time than those found in normal controls. Similar results were demonstrated in our study, but the difference between the severe and the mild fatigue polio groups were not significant. Furthermore, in the present study, electrophysiological correlates of information processing did not reveal any group differences in ERP measures reflecting the investment of attentional resources to task-relevant stimuli.

As to the correspondence between complaints of cognitive deficits in post-polio survivors and persons with chronic fatigue, the cognitive impairments are relatively subtle and are primarily in the areas of complex information processing speed and/or efficiency. In a review article, Tiersky et al. (10) stated that it is well known from studies with various patient populations (e.g. multiple sclerosis, mild traumatic brain injury, depression) that the number and severity of subjective complaints are disproportionate to objective neuropsychological deficits, and are associated with increased affective disturbances (particularly depression). Grace et al. (8) supported the same conclusion in a study on cognitive deficits in patients with the fibromyalgia syndrome, highlighting the significant correlation between memory and concentration measures and scores on questionnaires of pain and trait anxiety. According to Grace et al. multidisciplinary treatment programs are warranted. Tiersky et al. suggest that chronic fatigue syndrome patients with psychiatric complications may benefit from psychotherapy and/or psychopharmacological interventions, while those cognitively impaired without psychiatric comorbidity may benefit from a psychoeducational approach to symptom management and cognitive rehabilitation (10). The same may hold true for polio survivors experiencing fatigue without physical or medical problems.

The results of the physical exercise test in the present study are in accordance with the study by Schanke (32), showing that the maximal O_2 uptake did not correlate significantly with perceived fatigue. Compared with the study by Stanghelle et al. (38), where cardiorespiratory deconditioning was considerable in most subjects with post-polio syndrome, we also found that the polio subjects in the present study had a severe deconditioning. In a 5-year follow-up study of 63 polio patients by Stanghelle & Festvåg (39) cardiorespiratory deconditioning worsened, and mean body weight increased. However, subjective fatigue was not directly correlated to these conditions, as could be expected in persons with many additional health problems.

In conclusion, the present study highlights that attention should be given to assess psychological distress and depression when fatigue is reported among polio survivors. In our study,

other diseases or health problems were ruled out as possible explanations. Further, our study does not support the general notion that perceived fatigue in polio survivors corresponds to physical function and test results. Thus, fatigue should not be accepted as "normal" for polio survivors, but should be questioned. The implication of the present study is that medication, psychotherapy and psychoeducational programs may be useful when psychological distress is confirmed and seems to be a crucial factor mediating fatigue. However, the results in this study have been based on a rather limited number of polio subjects and similar studies from other centres are warranted.

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