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ORIGINAL REPORT

POST-POLIO SYNDROME: FATIGUED PATIENTS A SPECIFIC SUBGROUP?

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Objectives: **To examine the characteristics of fatigued and non-fatigued post-polio patients and to define potential subgroups across the fatigue continuum.**
Design: **Multi-centre study.**
Subjects: **A total of 143 post-polio patients were subdivided on the basis of percentile distribution into a fatigue group, a intermediate group, and a non-fatigue group, using the Multi Fatigue Inventory 20 general fatigue ratings.**
Methods: **Data on background, quality of life, fatigue and pain were collected. Descriptive statistics and correlations in each group and analysis of variance and χ^2 for group comparisons were performed. Non-linear regressions were employed to evaluate differences in the strength of associations between physical and mental fatigue, on the one hand, and vitality on the other.**
Results: **The fatigued group was younger, had shorter polio duration, more pain, higher body mass index, lower quality of life and was more physically and mentally fatigued. A higher proportion of this group had contracted polio after 1956 and was under 65 years of age. Mental fatigue had a relatively higher explanatory value than physical fatigue for differences in vitality in the fatigued group, whereas reversed patterns were seen in the other groups.**
Conclusion: **Fatigued post-polio patients can be considered as a subgroup.**

Key words: post-polio; fatigue; subgroup; physical fatigue; mental fatigue; vitality.

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INTRODUCTION

Post-polio syndrome (PPS) is characterized by increased or new health problems following a stable period of 15 years or more (1–3). The most common health problems are fatigue, increasing muscle weakness and pain in muscles and joints. Fatigue has been described as the most frequent symptom (1, 2), occurring in around two-thirds of patients (4–6). However, one-third of PPS patients do not experience fatigue.

There are two aspects of fatigue related to PPS: central fatigue and peripheral fatigue (7). Central fatigue, often leading to mental fatigue, involves the central nervous system (CNS), whereas peripheral fatigue derives mainly from the peripheral nervous system, that is, the motor units (8). It has been suggested that fatigue in PPS could be explained by the polio infection affecting the reticular activating system (RAS), thus leading to mental fatigue (9). Mental fatigue relates to difficulties with cognitive functions, such as planning and inhibition and problems with concentration and mental sustainability (10). In a study by Bruno et al. (9), PPS patients were found to have cognitive difficulties, including problems with attention and information processing speed. Other studies do not confirm the presence of cognitive dysfunction in PPS patients, indicating that mental fatigue is a minor problem. Results from a study by Hazendonk & Crow (11), indicated that PPS patients may have minor problems with inhibition compared with controls, but no other deficits could be detected, and, in a study by Östlund et al. (12) no cognitive differences were found in a comparison of fatigued and non-fatigued PPS patients.

However, there is evidence supporting that CNS is affected in PPS, Gonzales et al. (13) as well as Fordyce et al. (14) have reported an inflammatory process in the CNS and in peripheral blood in PPS patients. Intravenous immunoglobulin (IVIG) infusion dampened the inflammatory process and, in parallel, there was an increase in quality of life (QOL) especially in the sub-domain of vitality (13, 15, 16). In a recent study by Östlund et al. (17) two-thirds of the experience of vitality in a group of PPS patients was explained by level of general fatigue. More than 90% of the variation associated with general fatigue had a physiological background; that is, most of the perception of vitality in PPS is of a physiological and not a mental character. This was supported by the results of the studies of Schanke & Stanghelle (4) and Trojan & Cashman (2).

PPS patients have an enlarged motor unit area, due to ongoing denervation compensating changes, which have taken place in the motor units over a period of decades. The failing capacity of the motor neurone to reinnervate leads to a decrease in muscle strength in PPS patients, which also is a reason for an increased physical fatigue experienced by PPS patients (18, 19). Therefore polio duration, i.e. the time since the acute polio, may be considered as a predictor of PPS (20).

In order to understand the background of fatigue it is important to take an integrated approach (21) and, in the case of PPS,

to address the question as to whether fatigue in PPS originates from the CNS, the peripheral nervous system, or both. Even if earlier studies indicate that fatigue in PPS is due mostly to physical factors, the existence of ongoing inflammation may lead to a subjective experience of mental fatigue and thus cannot entirely rule out even a central background of fatigue in this patient group.

Although fatigue is a common symptom in PPS, not all patients with PPS are fatigued. It is therefore of clinical interest to examine the existence of subgroups of PPS patients based on their level and type of fatigue.

The aim of this study was therefore to analyse the characteristics of fatigued and non-fatigued PPS patients and to evaluate the central and peripheral backgrounds of fatigue, defined in this study as mental and physical fatigue. This was performed by means of evaluating potential differences in the strength of associations between mental and physical fatigue, on the one hand, and vitality on the other, in fatigued and non-fatigued PPS patients as well as in a intermediate group consisting of PPS patients who were neither fatigued nor non-fatigued.

METHODS

Participants

In total 143 patients, participating in a Swedish multicentre study (13, 17) were selected for this study. The study took place between 13 August 2002 and 24 June 2003. Inclusion criteria were: (*i*) a prior polio infection and 18–75 years of age; (*ii*) increasing muscle weakness/difficulties/pain after a stable period of at least 15 years; (*iii*) a variation in weight of not more than ± 7 kg during the past 5 years; and (*iv*) an ability to stand and walk 2 m with or without walking aids. For a more detailed flow-chart, see Gonzales et al. (13). The age range of the participants was 25–75 years.

Assessments

Assessment of the participants was carried out within a time span of 1–5 weeks, as described previously (13, 17). Only information pertaining to the present study is described here.

The participants provided demographic and background information and, from this, information about gender, age, year of polio and polio duration was included in the present study. Information about level of working was collected afterwards via medical records and was labelled Occupational/employment level. In order to calculate number of participants working in the open labour market in each group, the participants who were receiving a retirement pension, i.e. were 65 years of age or older, were excluded from the statistical analysis of Occupational/employment level. Unemployment was defined as non-working but still belonging to the workforce.

Participants were administered self-report inventories about fatigue and quality of life. The 20-item Multi Fatigue Inventory 20 (MFI-20) measures 5 different aspects of fatigue: general fatigue, physical fatigue, mental fatigue, reduced motivation and reduced activity. The statements refer to qualities of fatigue sensed during the previous days. A higher score on a 5-point Likert scale indicates a higher level of fatigue. The minimum score is 4 and maximum score is 20 within each item (22). MFI-20 has been considered as a reliable instrument for measuring fatigue, both in different patient populations and in healthy individuals (23).

The health-related QOL inventory Short Form-36 (SF-36) comprises 36 questions assessing QOL along 8 dimensions: physical function, role-physical, bodily pain, general health, vitality, social function, role-emotional and mental health. A score of 0–100 is calculated for each health concept or dimension, with a higher score indicating better QOL (24).

Pain was assessed by means of a 100-mm visual analogue scale (VAS), where zero mm represents no pain and 100 mm the worst imaginable pain (25, 26).

The Sleep Quality Scale (SQS), used for assessing sleep quality, is a 3-question inventory. Questions covered difficulty falling asleep, waking up during the night and disturbed sleep. A higher score on a 4-point Likert scale indicates worse sleep problems (27). All 3 subscales were highly correlated (r_s 371, 480, 639) ($p_s < 0.01$) and were therefore collapsed into a single variable (minimum value 3, maximum value 12) labelled Sleep quality total (SQST).

Physical Activity for the Elderly (PASE) is considered as a valid instrument of measurement of physical activity, especially in persons 65 years of age and older, over a one-week period. The instrument consists of a total of 10 questions, whereby participation in leisure activities (6 questions) are recorded as never/seldom (1–2 days a week), sometimes (3–4 days a week) and often (5–7 days a week). Duration is categorized as less than 1 h, 1–2 h, 2–4 h and more than 4 h. Paid or unpaid work (4 questions) is recorded as hours/week. Type of work, for example housework, gardening and caring for others, are recorded as yes/no. Scores are calculated from weight and frequency values and range from 0 to 400 or more. A higher total score indicates more physical activity. Preliminary norms in the age group 65–69 years of age are 144 ± 58.6 for men and 112.7 ± 64.2 for women (28, 29).

Groups

The total sample was subdivided on the basis of percentile distribution of the MFI General Fatigue score into 3 groups. By choosing participants with a score of 18–20 (Fatigued), 12–17 (Intermediate) and 4–11 (Non-fatigued), these 3 groups were created (see Table I). There were 38 participants (26.6%) in the fatigued group, 68 (47.6%) in the intermediate group, and 37 (25.9%) in the non-fatigued group.

Variables

Variables in this study that were considered clinically relevant were background variables capturing the most common symptoms in PPS. Variables concerning life aspects that might affect the experience of fatigue were also included. General fatigue from MFI-20 acted as a grouping variable. The variables were gender, age, polio duration, body mass index (BMI), SQST, pain and occupation/employment level. Using the year of acute polio, the number of participants who contracted polio after 1956 was calculated for each group. This was the year when polio vaccine was introduced in Sweden and, thus, contracting acute polio after 1956 lowers the likelihood of having been infected by polio in Sweden. Variables from the MFI-20 inventory were: physical fatigue and mental fatigue, and from the SF-36 inventory: physical function vitality and mental health.

Statistical analyses

All statistical analyses were performed using SPSS software package for Windows (version 15.0). Descriptive statistics and correlations, using Spearman non-parametric tests were performed for all the variables included in the study and for each group, respectively. A Spearman non-parametric test was performed for MFI-20 General fatigue and SF-36 Vitality for the entire sample. A significance test of the critical correlations MFI-20 Mental fatigue, Physical fatigue and SF 36 Vitality was performed across the 3 groups. Analysis of variance (ANOVA) and Tukey tests were performed for analyses of group comparisons of gender, age, polio duration, BMI, pain, SQST, Physical fatigue, mental fatigue, physical function, vitality and mental health and PASE. χ^2 was used for group comparison of Occupation/employment level. In order to evaluate potential differences in the strength of associations between mental and physical fatigue, on the one hand, and vitality on the other, linear and non-linear regressions were performed in the 3 groups, respectively.

Table I. *Descriptive data for all variables*

Variables	Fatigue $n=38$ Percentiles $25^{th} – 50^{th} – 75^{th}$	Intermediate $n=68$ Percentiles $25^{th} – 50^{th} – 75^{th}$	Non-fatigue $n=37$ Percentiles $25^{th} – 50^{th} – 75^{th}$	Fatigue vs intermediate	Fatigue vs non-fatigue	Intermediate vs non-fatigue
Female, %	63.2	64.7	64.9	ns	ns	ns
Age, years	49 – 57.5 – 63	57 – 62.5 – 67	58 – 63 – 67.5	$p<0.001$	$p<0.001$	ns
Polio duration, years	46.7 – 51.5 – 57	51 – 57 – 58.5	49.9 – 55 – 58.5	$p<0.05$	$p<0.05$	ns
65 years of age and older, %	18.4 $n=7/38$	39.7 $n=27/68$	45.9 $n=17/37$	–	–	–
Missing information (employment/pension), %	2.6 $n=1/38$	1.5 $n=1/68$	2.7 $n=1/37$	–	–	–
Occupation/employment level (excluded, 65≤years of age), %	67.7 $n=21/31$	65.8 $n=27/41$	72.2 $n=13/18$	ns	ns	ns
Occupation/employment level (all included), %	55.6 $n=21/38$	39.7 $n=27/68$	35.1 $n=13/37$	–	–	–
Working 100%, %	28.9 $n=11/38$	22 $n=15/68$	8.1 $n=3/37$	–	–	–
Working 75%, %	2.6 $n=1/38$	4.4 $n=3/68$	0 $n=0/37$	–	–	–
Working 50%, %	18.4 $n=7/38$	11.7 $n=8/68$	16.2 $n=6/37$	–	–	–
Working 25%, %	5.3 $n=2/38$	1.5 $n=1/68$	8.1 $n=3/37$	–	–	–
Unemployed, %	0 $n=0/38$	0 $n=0/68$	2.7 1/37	–	–	–
Sick leave, %	2.6 $n=1/38$	1.5 $n=1/68$	0 $n=0/37$	–	–	–
Pension before 65 years of age, %	21 $n=8/38$	17.6 $n=12/68$	16.2 $n=6/37$	–	–	–
Polio age <1956, %	18.4 $n=7/38$	2.9 $n=2/68$	0 $n=0/37$	–	–	–
BMI, %	23.8 – 26.5 – 27.5	23.6 – 25 – 27	22.5 – 24 – 26.6	ns	$p<0.05$	ns
VAS pain	23 –51 – 62	5.5 – 23 – 41	2 – 8 – 8.5	$p<0.000$	$p<0.000$	$p<0.000$
SF-36 Physical function	15 – 30 – 45	25 – 35 –55	45 – 55 –75	ns	$p<0.000$	$p<0.001$
SF-36 Vitality	15 – 25 – 35	36.2 – 50 – 69	67.5 – 80 – 90	$p<0.000$	$p<0.000$	$p<0.000$
SF-36 Mental health	47 – 64 – 77	64 –72 – 84	88 – 92 – 100	$p<0.001$	$p<0.000$	$p<0.000$
MFI-20 Physical fatigue	16 – 18 – 20	12 – 14 – 17	6 – 8 – 11	$p<0.000$	$p<0.000$	$p<0.000$
MFI-20 Mental fatigue	9 – 12 – 16	8 – 10 – 12	4.5 –7 – 8.5	$p<0.05$	$p<0.000$	$p<0.000$
Sleep Quality Scale total	6 – 9 – 11	6 – 8 – 10	5 – 7 – 8.5	ns	$p<0.001$	ns
PASE	35 – 72 – 119 Missing=4	56.9 – 87 – 132.4 Missing=6	59 – 93.8 – 138 Missing=3	ns	ns	ns

BMI: body mass index; VAS: visual analogue scale; SF-36: Short Form-36; MFI-20: Multi Fatigue Inventory 20; PASE: Physical Activity for the Elderly; ns: not significant.

The study and all procedures were approved by the ethics committee at Karolinska Institutet, and conducted in accordance with the Helsinki Declaration of 1975.

RESULTS

Descriptive results are shown in Table I. There were no significant group differences in distribution of men and women in the 3 groups. The patients in the fatigued group were significantly younger, had shorter polio duration, more pain, lower physical function and lower vitality compared with the reference and non-fatigued group, respectively. BMI was significantly higher in the fatigued group compared with the non-fatigued group. They also scored lower on mental health even if the score did not indicate any clear problems with mental health according to the SF-36 manual. The fatigued group also scored higher on physical fatigue, and mental fatigue, and the variable SQST indicated more sleep problems. The non-fatigued patients had lower VAS pain and higher vitality than the controls. There were no significant differences between the 3 groups according to physical activity measured by PASE. However, the fatigued group had a slightly lower score than the other two groups, indicating a lower physical activity level.

When all patients where included there were more participants in the fatigued group who were working (55.6%) compared with the intermediate group (39.7%) and the non-fatigued group (35.1%). As seen in Table I, employment status in each group varies from working at a 25% level to working full-time, with slightly more patients in the fatigued group working full-time. There were 7 (18.4%) patients on retirement pension in the fatigued group, 27 (39.7%) in the intermediate group and 18 (45.6%) in the non-fatigue group. When all patients aged 65 years and older were excluded no significant differences between the 3 groups in frequency of active working could be found. Seven (18.4%) of the patients in the fatigued group has been contracted polio after 1956, compared with 2 (2.9%) in the intermediate group and none (0%) in the non-fatigued group. MFI-20 General fatigue and SF-36 vitality in the total sample ($n=143$) were highly correlated (r_s –0.837, $p_s<0.0001$) and indicate that an increase in general fatigue level is associated with a decrease in SF-36 vitality score.

Table II show correlations of vitality, VAS pain, physical fatigue and mental fatigue, in the fatigue, reference, and non-fatigue groups, respectively. A significant test of the critical correlations MFI-20 mental fatigue and physical fatigue with vitality across groups showed that the correlation mental fatigue with vitality differed significantly between the fatigued and non-fatigued groups ($p=0.0257$). Physical fatigue and vitality did not differ significantly across groups; however, there was a tendency towards significance between the fatigue and non-fatigue groups ($p=0.0615$) and fatigue and intermediate groups ($p=0.0777$) compared with non-fatigue and intermediate groups ($p=0.7040$).

Table II. *Spearman correlations*

Variables	1 Gender	2 Age	3 Polio duration	4 BMI	5 VAS pain	6 Physical function	7 Vitality	8 Mental health	9 Physical fatigue	10 Mental fatigue	11 Sleep quality total	12 PASE[b]
Fatigue group												
1. Gender[a]	1											
2. Age	0.254	1										
3. Polio duration	0.207	0.833**	1									
4. BMI	0.035	–0.002	0.022	1								
5. VAS pain	–0.080	–0.077	0.073	0.071	1							
6. Physical function	–0.292	–0.077	0.000	–0.329*	–0.136	1						
7. Vitality	0.121	–0.045	–0.136	–0.048	0.064	0.038	1					
8. Mental health	–0.137	0.044	0.030	–0.193	–0.129	0.216	0.063	1				
9. Physical fatigue	0.059	0.005	–0.091	0.297	0.300	–0.536**	–0.209	–0.007	1			
10. Mental fatigue	–0.067	–0.158	–0.132	–0.075	–0.136	–0.008	0.118	–0.400*	–0.119	1		
11. Sleep quality total	0.402*	0.037	0.205	0.468**	0.265	–0.487**	–0.037	–0.299	0.232	–0.057	1	
12. PASE[b]	0.161	–0.072	–0.070	–0.097	0.175	0.234	0.121	–0.137	0.059	–0.067	0.402	1
Intermediate group												
1. Gender[a]	1											
2. Age	–0.090	1										
3. Polio duration	0.000	0.491**	1									
4. BMI	–0.047	0.004	0.117	1								
5. VAS pain	0.191	–0.054	–0.012	0.007	1							
6. Physical function	–0.183	–0.134	0.003	–0.122	–0.222	1						
7. Vitality	–0.061	0.106	0.044	–0.014	–0.216	0.210	1					
8. Mental health	–0.113	–0.007	–0.097	0.161	–0.174	0.044	0.532**	1				
9. Physical fatigue	0.032	–0.012	–0.049	0.049	0.276*	–0.334**	–0.524**	–0.103	1			
10. Mental fatigue	0.009	–0.129	–0.096	0.093	0.081	0.021	–0.157	–0.369**	0.025	1		
11. Sleep quality total	0.135	0.091	0.149	0.118	0.272*	–0.030	–0.211	–0.315**	0.159	0.299*	1	
12. PASE[c]	–0.063	–0.356**	–0.168	–0.138	0.043	0.369	0.175	0.090	–0.275*	0.135	–0.145	1
Non-fatigue group												
1. Gender[a]	1											
2. Age	–0.112	1										
3. Polio duration	–0.204	0.404*	1									
4. BMI	–0.138	0.132	0.364*	1								
5. VAS pain	0.133	–0.031	–0.043	0.076	1							
6. Physical function	–0.138	0.170	0.138	0.169	–0.004	1						
7. Vitality	–0.272	0.208	–0.071	0.052	–0.384*	0.362*	1					
8. Mental health	–0.256	0.147	–0.037	–0.027	–0.448**	0.267	0.772**	1				
9. Physical fatigue	0.417*	–0.231	–0.120	–0.042	0.513**	–0.411*	–0.580**	–0.509**	1			
10. Mental fatigue	0.231	–0.115	–0.015	–0.107	0.562**	–0.045	–0.395*	–0.319	0.559**	1		
11. Sleep quality total	0.313	–0.071	0.062	–0.035	0.300	–0.127	–0.173	–0.159	0.395*	0.437**	1	
12. PASE[d]	–0.136	–0.112	0.188	0.162	–0.080	0.304	0.221	0.053	–0.289	0.225	–0.110	1

*$p<0.05$; **$p<0.01$.
[a]Calculated by biserial correlation.
PASE missing: [b]$n=4$; [c]$n=6$; [d]$n=3$.
BMI: body mass index; VAS: visual analogue scale; PASE: Physical Activity for the Elderly.

In the fatigued group, no significant correlations for vitality or for VAS pain were seen. Increasing physical fatigue was associated with lower physical function and increasing mental fatigue with lower mental health.

In the intermediate group, increasing vitality was associated with increasing mental health and lower physical fatigue. Increasing VAS pain was associated with increasing physical fatigue and lower sleep quality. Increasing physical fatigue was associated with increasing VAS pain, lower physical function and lower vitality, and, increasing mental fatigue was associated with lower mental health and worse sleep quality.

In the non-fatigue group, increasing polio duration was associated with higher BMI. Increasing vitality was associated with higher mental health. Decreasing vitality was associated with higher physical fatigue and more mental fatigue. Increasing pain was associated with lower vitality, lower mental health and higher physical and mental fatigue. Increasing physical fatigue was associated with being a woman, with more pain, lower physical function, lower vitality, lower mental health, higher mental fatigue and worse sleep quality. Finally, increasing mental fatigue was associated with more pain, lower vitality, higher physical fatigue and worse sleep quality. As can be concluded from the table, the number of correlations between clinically important variables in PPS patients decreased with increasing fatigue in this study.

The relative importance of mental and physical fatigue for vitality in the 3 groups is presented in Table III. In the fatigued group, mental and physical fatigue explained 9.8%

Table III. *Regressions for 20-item Multi Fatigue Inventory 20 Physical fatigue and Mental fatigue with Short Form-36 Vitality as dependent variables, in the fatigue, intermediate and non–fatigue groups*

Dependent	Group	Independent	R^2 = linear	R^2 = quadratic	R^2 = cubic
Vitality					
	Fatigue, n = 38	Physical fatigue	0.022	0.04	0.059
		Mental fatigue	0.021	0.084	0.098
	Intermediate, n = 68	Physical fatigue	0.235	0.399	0.399
		Mental fatigue	0.02	0.09	0.119
	Non-fatigue, n = 37	Physical fatigue	0.307	0.31	0.456
		Mental fatigue	0.183	0.186	0.189

and 5.9%, respectively, of the variation in vitality. In the intermediate group, mental and physical fatigue explained 11.9% and 39.9%, respectively, of the variation in vitality. In the non-fatigued group, mental and physical fatigue explained 18.9% and 45.6%, respectively, of the variation in vitality. Hence, mental fatigue had, in the fatigue group, a relatively greater importance than physical fatigue for vitality, even if the difference was small. The reverse patterns were found in the intermediate and non-fatigue groups, where physical fatigue had relatively greater importance than mental fatigue. Interestingly, all these associations were best described by a cubic function in all 3 groups.

DISCUSSION

The aim of this study was to characterize fatigued and non-fatigued PPS patients in order to evaluate central and peripheral backgrounds of fatigue, defined as mental and physical fatigue. The results show that the fatigued group differed from both the intermediate and non-fatigued PPS groups. In the study by Östlund et al. (17) most of the perception of vitality in PPS was of physiological character; that is, fatigue in PPS patients is mostly experienced as physical. There is a continuous loss of motor neurones in PPS patients, starting earlier than in healthy individuals, resulting in increasing muscle weakness and/or fatigue (30). In normal ageing, the loss of motor neurones starts at the age of approximately 60 years, with a loss of approximately 1.9% per year (31), this normal process is also ongoing in PPS patients in parallel with a PPS-associated motor neurone loss in affected limbs (18, 19, 30). In a study by Schwartz et al. (32), the experience of general fatigue tended to increase almost linearly with increasing age in the general population. Due to this, we expected the fatigued PPS patients to be older and to have longer polio duration. However, the fatigued group in this study was significantly younger and had shorter polio duration than both the intermediate and non-fatigue groups. Only approximately one-fifth of the fatigued group, but almost half of the non-fatigue group were receiving retirement pension. This result indicates that fatigue in PPS, in some aspects, may be separate, both from normal increasing fatigue experienced with increasing age and from time since acute polio onset. This finding is supported by the results of a study by Schanke & Stanghelle (4) where no age differences between a non-fatigue and a severe fatigue group of PPS patients were seen. Vitality has even been found to increase with increasing age in PPS patients (17). Furthermore, this is in line with a study by Nollet et al. (33) where fatigue levels were lower after a 6-year follow-up compared with baseline levels. The higher age in the non-fatigued group of the present study could be due to new coping strategies and a successful adaptation to a new situation, i.e. a response shift (34, 35). However, examination of this hypothesis requires further study.

Besides age, concomitant disorders may lead to fatigue, both of mental and physical character. The use of SF-36 in the present study did not allow us to evaluate concomitant disorders. In a study by Tate et al. (36) PPS patients with depression reported more pain, lower QOL, feelings of loneliness and lower coping behaviour. However, depression, which may be an obvious reason for fatigue, has not been reported to have a higher frequency in PPS patients than in the general population (37). Cardiovascular and pulmonary diagnoses may be another cause of increasing fatigue. Thus, it would be expected that fatigue would increase with age, since these diagnoses increase with age. However, the opposite was found in the present study, and this would be an argument against concomitant disorders as background for the fatigue in the fatigued group.

In all 3 groups, physical fatigue was increased more than mental fatigue. This is in agreement with the results of several studies in which physical fatigue has been highlighted as one of the most pronounced problems in PPS (4, 17, 33). Physical fatigue cannot be due only to a decreasing decompensation process in the motor neurone, but also to an increased speed of loss of the motor neurone (7, 18) an overuse of muscles (2) or an ongoing inflammatory process in the CNS (13, 14). The fatigued group had significantly more physical and mental fatigue compared with the intermediate and non-fatigued groups. However, in the fatigued group mental fatigue had a relatively greater importance than physical fatigue for vitality, even if the amount of variance accounted for, and the difference between physical fatigue and mental fatigue, was small compared with the non-fatigued and intermediate groups. In the non-fatigued and intermediate groups the pattern was reversed. This suggests that the fatigued group is not just descriptively different, but also that the mechanisms behind variation in vitality are different. Interestingly, the finding that the cubic trends accounted for most of the vitality-related variations in all groups points to the existence of still other groups across the fatigue continuum. In order to explore this further larger samples than that available for the present study are required.

Mental fatigue affects cognitive functions such as planning and inhibition and is related to mental sustainability and to the ability to concentrate, but it does not affect skills that are more

automatic. This is a normal experience in healthy individuals after mental effort (10) or lack of sleep. Sleep problems are reported as a common symptom in PPS patients. In a study by van Kralingen et al. (38) almost 50% of the PPS patients reported disordered sleep. In the present study, the fatigued group had significantly worse sleep quality than the reference and non-fatigued groups. Lichstein et al. (39) differentiate between fatigue and daytime sleepiness as separate phenomena. It is important to consider this difference, since treatment and coping strategies are not the same. Sleep quality can also be affected by pain, which is another pronounced symptom in PPS. The fatigued group in the present study had significantly higher pain scores than both intermediate and non-fatigued groups. It is known that pain lowers a person's energy levels and may affect mental health, since coping with constant pain is demanding and often affects both sustainability and concentration/attention (40). However, in the present study, neither vitality nor pain correlated significantly with any variables in the fatigued group; instead we found that the less fatigued the group the more expected correlations occurred.

In the present study 20% of the fatigued group, none of the non-fatigued group and 3% of the intermediate group had contracted polio after 1956. This was the introduction year for polio vaccine in Sweden, and we therefore considered that contracting polio after this year increases the likelihood of having acquired polio outside Sweden. According to a study by Thorén-Jönsson et al. (41), immigrants with PPS had more problems with pain and emotional distress than did non-immigrants. In the present study the fatigue group had worse mental health compared with the non-fatigued and intermediate groups. However, even if the score were elevated, they did not indicate mental health problems (23).

There were no differences regarding occupation/employment between the groups when all participants over 65 years of age were excluded, even if the fatigued group had a tendency to work more full-time than the other two groups. All 3 groups scored higher on physical fatigue than mental fatigue and the source of physical fatigue may be both peripheral and central. However, only in the fatigued group had mental fatigue a relatively larger importance than physical fatigue for vitality. The questions as to why mental fatigue is of greater importance in the fatigued group and whether non-fatigued polio survivors diagnosed with PPS will experience fatigue during their lifetime may be subjects for further studies.

In conclusion, based on these statistical analyses, fatigued PPS patients may be considered as a subgroup, characterized by significantly lower age, more physical problems and lower QOL than intermediate and non-fatigued groups. Mental fatigue is also of relatively greater importance for vitality than is physical fatigue in fatigued patients.

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