

# Post-polio syndrome: epidemiologic and prognostic aspects in Brazil

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**Objectives** – To describe the clinical and epidemiological aspects of post-polio syndrome (PPS) and identify predictors of its severity. **Materials and methods** – 132 patients with PPS were selected at the Neuromuscular Disease Outpatient Clinic of the Federal University of São Paulo. Descriptive analysis was carried out and predictors of PPS severe forms were investigated using an unconditional logistic regression. **Results** – The average age at onset was 39.4 years. The most common symptoms were fatigue (87.1%), muscle pain (82.4%) and joint pain (72.0%); 50.4% of the cases were severe. The following were associated with PPS severity: a ≤4-year period of neurological recovery (OR 2.8), permanent damage in two limbs (OR 3.6) and residence at the time of acute polio in a city with more advanced medical assistance (OR 2.5). **Conclusions** – Health professionals should carefully evaluate polio survivors for PPS and be aware of the implications of muscle overuse in the neurological recovery period.

**M. T. R. P. Conde<sup>1,2</sup>, A. S. B. Oliveira<sup>2</sup>, A. A. J. Quadros<sup>2</sup>, G. A. Moreira<sup>3</sup>, H. C. A. Silva<sup>2</sup>, R. D. B. Pereira<sup>2</sup>, T. M. e Silva<sup>2</sup>, S. Tufik<sup>3</sup>, E. A. Waldman<sup>1</sup>**

<sup>1</sup>School of Public Health, University of São Paulo, São Paulo, Brazil; <sup>2</sup>Department of Neuromuscular Diseases, Paulista School of Medicine, Federal University of São Paulo, São Paulo, Brazil; <sup>3</sup>Sleep Institute, Paulista School of Medicine, Federal University of São Paulo, São Paulo, Brazil

Key words: Brazil; disease severity; post-polio syndrome; predictive factors

Eliseu Alves Waldman, Departamento de Epidemiologia, Faculdade de Saúde Pública da Universidade de São Paulo, Av. Dr Arnaldo, 715, Cerqueira César, São Paulo, SP, CEP 01246-904, Brazil  
Tel.: +55 11 3061 7109  
Fax: +55 11 3082 2920  
e-mail: eawaldma@usp.br

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## Introduction

The many survivors of the polio epidemics that occurred worldwide in the mid-20th century constitute a population at risk of presenting post-polio syndrome (PPS) (1, 2). By aggravating the motor sequelae of polio, PPS reduces functional capacity, thereby negatively affecting patient's quality of life, as it limits individual autonomy in performing activities of daily living (3).

Predictors of PPS include occurrence of the acute phase of polio at an older age, greater severity during that phase, greater recovery and more extensive sequelae after recovery (4). In Brazil, the worst polio epidemics occurred in the 1950s and 1960s (5). Until the elimination of polio in the 1980s, 90% of the cases in Brazil affected children under 4 years of age, while the high-risk age group in developed countries was higher (6, 7). In view of this fact, it is possible that PPS in Brazil presents behavior distinct from that observed in developed countries where the disease has been much studied (8–12). However, there have been

few studies on PPS in Brazil. Of the few that have been conducted, two were descriptive studies focusing on clinical aspects: one was a case-series study (13); and the other compared patients diagnosed with PPS according to the Mulder et al. criteria (14) and patients with asymptomatic polio sequelae in terms of clinical symptomatology (15). The objective of the present study was to describe the principal clinical and epidemiological aspects of PPS in Brazil and to identify factors associated with its severity.

## Methods

This was a descriptive study of a series of cases and of the prognostic factors of PPS. The population of interest included patients diagnosed with PPS between January 2003 and December 2006 at the Neuromuscular Disease Outpatient Clinic of the Universidade Federal de São Paulo/Escola Paulista de Medicina (UNIFESP/EPM, Federal University of São Paulo/Paulista School of Medicine), located in the city of São Paulo.

## Definitions

A case of paralytic polio was defined as an individual who presented sequelae (residual atrophy with paralysis or paresis, areflexia and normal sensitivity in at least one limb), together with electromyographic alterations consistent with polio.

Cases of PPS were defined as patients presenting the following (16):

- a history of paralytic polio;
- new symptoms after a period of functional stability of at least 15 years;
- new weakness accompanied by other neuromuscular symptoms;
- persistence of symptoms for 1 year;
- no other diseases that might explain the new symptoms and clinical signs.

Severe cases of PPS were defined as individuals who, after new muscle weakness, were diagnosed with sleep apnea unrelated to other factors (17) and had an apnea/hypopnea index (AHI) of 15 or more events per hour on the polysomnography test (18). Those who, after new muscle weakness, required assistance in walking (orthosis, crutches, walker or cane) or a wheelchair were also classified as having severe PPS (19).

Patients who met the definition established for a case of paralytic polio and PPS were included in the study, regardless of gender. Patients aged 60 years or older or who had other diseases that could lead to muscle weakness were excluded.

Serum creatine kinase (CK) levels were classified as normal ( $\leq 170$  mg/dl), mildly elevated (171–340 mg/dl) or moderately to severely elevated ( $\geq 341$  mg/dl).

This study was approved by the Ethics Research Committee of the University of São Paulo School of Public Health, and all participating patients gave written informed consent.

The sources of data were the UNIFESP/EPM Neuromuscular Disease Outpatient Clinic and polysomnography records of the UNIFESP/EPM Sleep Institute.

The cases were selected through the review of 417 medical charts of patients with polio sequelae. The medical charts include data based on routine treatment obtained by medical appointments with physical therapists/neurologists and routine polysomnography, as well as, when necessary, laboratory testing, imaging and electromyography.

The data gathered from medical records were collected using a structured and precodified form. In order to determine whether the questions were well written and understandable, 20 patients

treated at the same outpatient clinic took a pretest using the form. These patients did not meet the inclusion criteria and were therefore not included in the analysis.

The data were stored with the EPIDATA program, version 3.1 (The EpiData Association, Odense M, Denmark), using double data entry. For the logistic regression, the STATA<sup>®</sup> program, version 9 (StataCorp LP, College Station, TX, USA), was used. The variables of interest were sociodemographic data, data related to the acute phase of polio (clinical and epidemiological aspects), data related to the recovery phase/functional stability of polio and data related to the characteristics (clinical and laboratorial aspects) of PPS.

## Data analysis

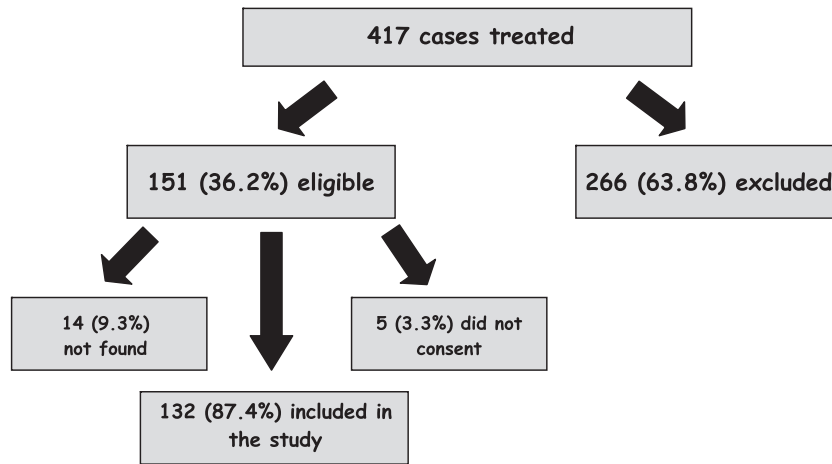
The descriptive analysis was carried out through comparisons of the proportions by category, together with the calculation of mean, median and standard deviation (SD). For comparisons of categorical variables, the chi-squared test and Fisher's exact test were used. For comparisons of continuous variables with normal distribution (tested using the Kolmogorov–Smirnov test), the Student's *t*-test and an analysis of variance were used. For those variables that did not present normal distribution, the Mann–Whitney and Kruskal–Wallis tests were used.

As a proxy (surrogate) of polio cases associated with the most pathogenic strains of the poliovirus, we used cases occurred in the polio epidemics years between 1945 and 1979, when the incidence rate was equal or greater than 4/100,000 inhabitants. As a proxy (surrogate) of access to rehabilitation after the acute phase, we considered residence at the time of the acute phase of the disease in state capitals or municipality where there are large university medical centers.

For the identification of the factors associated with the severe forms of the disease, crude and adjusted odds ratios (ORs) were used through unconditional logistic regression, with 95% confidence intervals. The statistical significance of the variables in the models was evaluated using the likelihood ratio test. For the evaluation of the adjustment for all variables analyzed, the Hosmer–Lemeshow goodness-of-fit test was used.

## Results

Of the 417 patients with sequelae of paralytic polio registered in the outpatient clinic, 151 met the criteria adopted for this study. Of those 151, 19



**Figure 1.** Schematic representation of data collection for the study. Neuromuscular Disease Outpatient Clinic at UNIFESP (Federal University of São Paulo)/EPM (School of Medicine of São Paulo), 2003–2006.

were excluded: five (3.3%) declined to participate and 14 (9.3%) were not found (Figure 1). Therefore, 132 patients were included in the final study sample. If we compare the 19 excluded patients with the 151 patients who met the inclusion criteria, the proportion of male patients and of those who were  $\geq 4$  years of age during the acute phase of polio was higher in the former group. The two groups were homogeneous for the remaining variables.

Of the 132 patients, 84 (63.6%) were female. Of the 131 patients for whom educational data were available, 100 (76.6%) had had more than 11 years of schooling. The average age at onset of new symptoms was 39.5 years (range 24–55 years) for men and 39.2 years (range 19–57 years) for women. The mean interval between symptom onset and diagnosis was 6.2 years, and between the new weakness and diagnosis was 5.4 years.

The most common symptoms were fatigue, muscle pain and joint pain, which were reported in 87.1%, 82.4% and 72% of the patients respectively. In analyzing the signs and symptoms by age bracket at the time of PPS diagnosis, we observed that weight gain prior to the new weakness was greater among patients diagnosed between 19 and 34 years of age ( $P < 0.05$ ) and fatigue was less common among those diagnosed between 43 and 57 years of age ( $P < 0.05$ ) (Table 1). New weakness occurred in all 132 cases and was found to be in the previously affected musculature in 123 (93.2%) of those cases. Among the 47 patients presenting new atrophy, the atrophy was found to be in the previously affected musculature in 44 (93.6%).

At the time of acute polio, the average age was 22.5 months (range 3 months to 17 years; median 17 months). Impairment of all four limbs was reported in 65 (51.6%) of the 126 patients for

whom such data were available. Of those 65 patients, 46/82 (56.1%) were female and 19/44 (43.2%) were male ( $P > 0.05$ ).

Hospitalization was more common among patients who had medullar and bulbar polio, occurring in 20 (74.1%) of the 27 patients presenting that profile, compared with 45 (43.7%) of the 103 who presented only medullar involvement ( $P < 0.005$ ). Hospitalization was also more common among patients contracting the disease during epidemic years, occurring in 45 (57%) of the 79 such patients than among those contracting the disease during non-epidemic years, occurring in 20 (38.5%) of the 52 such patients ( $P < 0.05$ ). Among the 65 patients residing in cities with greater access to more advanced medical assistance, 39 (60%) were hospitalized, compared with only 26 (39.4%) of the remaining 66 patients ( $P < 0.05$ ) (Table 2).

The maximum functional and neurological recovery occurred in 4.2 years (SD 3.9 years; median 3 years). The average period of functional stability was 33.4 years (SD 8.6 years; median 33.7 years).

Serum CK levels were determined in 111 patients. Moderate-to-severe elevation of serum CK occurred in 10/14 male patients (71.4%) compared with in 4/14 (28.6%) of the female patients ( $P < 0.05$ ). Mild elevation of serum CK occurred equally in both genders: male 19/33 (57.6%); female 14/33 (42.4%) ( $P > 0.05$ ). Normal serum levels of CK were observed in 53/64 (82.8%) of the female patients and in 11/64 (17.2%) of the male patients ( $P < 0.001$ ).

Of the 131 patients, 66 (50.4%) were classified as severe cases. Of those 66 patients, after the onset of the new weakness, 41 (62.1%) began requiring assistance to walk, 12 (18.2%) required wheel-

**Table 1** Prevalence of post-polio syndrome symptoms at the time of diagnosis according to age bracket at onset of symptoms. Neuromuscular Disease Outpatient Clinic at UNIFESP (Federal University of São Paulo)/EPM (School of Medicine of São Paulo), 2003–2006.

Symptom	19–34 years		35–42 years		43–57 years		Total		P-value
	n	%	n	%	n	%	n	%	
New atrophy									>0.05*
Absent	27	31.8	25	29.4	33	38.8	85	100.0	
Present	12	25.5	20	42.6	15	31.9	47	100.0	
Total	39	29.5	45	34.1	48	36.4	132	100.0	
Muscle pain									>0.05*
Absent	7	30.4	6	26.1	10	43.5	23	100.0	
Present	32	29.6	39	36.1	37	34.3	108	100.0	
Total	39	29.8	45	34.3	47	35.9	131	100.0	
Dysphagia (self-report)									>0.05†
Absent	35	30.2	36	31.0	45	38.8	116	100.0	
Present	4	25.0	9	56.2	3	18.8	16	100.0	
Total	39	29.5	45	34.1	48	36.4	132	100.0	
Fatigue									<0.05†
Absent	3	17.6	3	17.6	11	64.8	17	100.0	
Present	36	31.3	42	36.5	37	32.2	115	100.0	
Total	39	29.5	45	34.1	48	36.4	132	100.0	
Joint pain									>0.05*
Absent	8	21.6	12	32.4	17	46.0	37	100.0	
Present	31	32.6	33	34.8	31	32.6	95	100.0	
Total	39	29.5	45	34.1	48	36.4	132	100.0	
Intolerance to cold									>0.05*
Absent	21	34.4	22	36.1	18	29.5	61	100.0	
Present	18	25.3	23	32.4	30	42.3	71	100.0	
Total	39	29.5	45	34.1	48	36.4	132	100.0	
Weight gain (before the new weakness)									<0.05*
Absent	16	21.6	23	31.1	35	47.3	74	100.0	
Present	22	39.3	21	37.5	13	23.2	56	100.0	
Total	38	29.2	44	33.8	48	37.0	130	100.0	
Sleep disorders (self-reported)									>0.05*
Absent	22	32.9	21	31.3	24	35.8	67	100.0	
Present	17	26.2	24	36.9	24	36.9	65	100.0	
Total	39	29.5	45	34.1	48	36.4	132	100.0	
Respiratory disorders (self-reported)									>0.05†
Absent	34	31.8	33	30.8	40	37.4	107	100.0	
Present	5	20.0	12	48.0	8	32.0	25	100.0	
Total	39	29.5	45	34.1	48	36.4	132	100.0	

\*Chi-squared test.

†Fisher's exact test.

chairs and seven (10.6%) required non-invasive respiratory assistance equipment at night (bi-level positive airway pressure). In addition, two (3%) used both wheelchairs and non-invasive breathing assistance at night and four (6.1%) initially used walkers but subsequently required wheelchairs.

Of the 115 patients (87.1% of the total sample) who submitted to the polysomnography test, 33 (28.7%) presented sleep apnea, of which 31 (93.9%) had the obstructive type. There were nine patients who presented an AHI ≥15 events per hour and were classified as being severe cases of PPS. After the onset of new weakness, all nine of those patients required non-invasive respiratory assistance equipment at night (bi-level positive

**Table 2** Characteristics of post-polio syndrome cases according to hospitalization during the acute phase of poliomyelitis. Neuromuscular Disease Outpatient Clinic at UNIFESP (Federal University of São Paulo)/EPM (School of Medicine of São Paulo), 2003–2006.

Characteristic	Hospitalization				Total	P-value	%
	Absent (n = 66)		Present (n = 65)				
	n	%	n	%	n		
Type of poliomyelitis							<0.05*
Medullar	58	56.3	45	43.7	103	100.0	
Medullar and bulbar	7	25.9	20	74.1	27	100.0	
Total	65	50.0	65	50.0	130	100.0	
Year of epidemic							<0.05*
No	32	61.5	20	38.5	52	100.0	
Yes	34	43.0	45	57.0	79	100.0	
Total	66	50.4	65	49.6	131	100.0	
Age bracket (years)							>0.05*
<12	23	47.9	25	52.1	48	100.0	
12–23	17	45.9	20	54.1	37	100.0	
≥24	26	56.5	20	43.5	46	100.0	
Total	66	50.4	65	49.6	131	100.0	
Limbs affected							>0.05*
One	6	46.2	7	53.8	13	100.0	
Two	21	61.8	13	38.2	34	100.0	
Three	6	46.2	7	53.8	13	100.0	
Four	30	46.2	35	53.8	65	100.0	
Total	63	50.4	62	49.6	125	100.0	
Place of residence†							<0.05*
No	40	60.6	26	39.4	66	100.0	
Yes	26	40.0	39	60.0	65	100.0	
Total	66	50.4	65	49.6	131	100.0	

\*Chi-squared test.

†Refers to cities with access to advanced medical assistance and university medical centers.

airway pressure). However, only one of those patients had been submitted to respiratory support during the acute illness.

Of the 66 severe cases, 33 (50%) were between 41 and 59 years of age and 45 (68.2%) were female. Comparing severe cases with non-severe cases, there were no differences ( $P < 0.05$ ) regarding the prevalence of new atrophy, muscle pain, fasciculations, dysphonia (self-reported), fatigue, joint pain, intolerance to cold, weight gain and sleep disorders (self-reported). By contrast, the prevalence of dysphagia (self-report) and respiratory disorders (self-report) were higher among the severe group than among the non-severe group: 81.3% vs 18.7%; and 70.8% vs 29.2% respectively ( $P < 0.05$ ).

Normal serum CK levels were seen in 27/53 (50.9%) of the non-severe patients compared with 37/58 (63.8%) of the severe patients ( $P > 0.05$ ). Mild elevation of serum CK levels was seen in 17/53 (32.1%) of the non-severe patients, compared with 16/58 (27.6%) of the severe patients ( $P > 0.05$ ). Moderate-to-severe elevation of serum

CK levels was seen in 9/53 (17.0%) of the non-severe patients and in only 5/58 (8.6%) of the severe patients ( $P > 0.05$ ).

In the bivariate analysis, the following factors appeared to be associated with the severe forms of the disease: having had 15 or more years of schooling (OR 5.1), residing in a city with greater access to medical assistance at the time of acute polio (OR 2.7), having been 24 months of age or older during the acute phase of polio (OR 2.2), presenting permanent sequelae in two limbs (OR 2.7) and having experienced a period of functional recovery of  $\leq 4$  years (OR 2.1) (Table 3).

In the final model of the unconditional logistic regression analysis, the following exposures appeared to be independently associated with the severity of the disease: a period of neurological and functional recovery of  $\leq 4$  years (adjusted OR 2.8), residence in a city with better access to medical assistance during the acute phase of polio (adjusted OR 2.5) and sequelae in two limbs (adjusted OR 3.6) (Table 4).

**Discussion**

The first descriptions of PPS in Brazil appeared only recently (13, 15), and its real burden in the country is unknown. A formidable hurdle to the knowledge of the magnitude of PPS in Brazil is the limited familiarity of clinicians with the disease and the lack of knowledge that polio survivors have regarding the disease. These factors may explain, in part, the results of this study that suggest the delay of the diagnosis, more than 5 years after the onset of PPS.

The population studied was young and, as such, presented clinical manifestations that were not influenced by the age-related loss of motor skills. The profile of the patients was similar to that of one of the studies previously conducted in Brazil (15) and to those of two cohort studies, one conducted in the USA and other conducted in Italy (19, 20). However, our patient profile differs from that of most studies in the literature, in which older patients predominate (9, 21, 22).

The predominance of female patients (63.6%) in the PPS population studied is similar to that seen in the literature (12, 21) and in the studies conducted in Brazil (13, 15).

Regarding the clinical aspects, they did not differ from the descriptions found in the studies conducted in Brazil (13, 15) and in the literature. However, the frequency of symptoms was higher than that of previous studies (10, 13, 15, 23, 24). Nevertheless, the differences in methodology and in the definitions of PPS cases, which do not

**Table 3** Bivariate analysis of the factors associated with severity of post-polio syndrome. Neuromuscular Disease Outpatient Clinic at UNIFESP (Federal University of São Paulo)/EPM (School of Medicine of São Paulo), 2003–2006.

Characteristic	Severe (n = 131)			Crude OR (95% CI)
	No	Yes	Total	
Gender				
Male	26	21	47	1.0 (Ref.)
Female	39	45	84	1.4 (0.7–2.9)
Years of schooling*				
$\leq 7$	14	5	19	1.0 (Ref.)
8–10	6	6	12	2.8 (0.6–12.8)
11–14	28	23	51	2.3 (0.7–7.3)
$\geq 15$	17	31	48	5.1 (1.6–16.6)
Age bracket†				
$< 24$ months	48	37	85	1.0 (Ref.)
$\geq 24$ months	17	29	46	2.2 (1.1–4.6)
Type de poliomyelitis‡				
Medullar	55	49	104	1.0 (Ref.)
Medullar and bulbar	9	17	26	2.1 (0.9–5.2)
Limbs affected†				
One	7	7	14	1.0 (Ref.)
Two	18	16	34	0.9 (0.2–3.1)
Three	5	8	13	1.6 (0.3–7.4)
Four	30	34	64	1.1 (0.3–3.6)
Hospitalization†				
No	34	32	66	1.0 (Ref.)
Yes	31	33	64	1.1 (0.6–2.2)
Mechanical ventilation†				
No	56	49	105	1.0 (Ref.)
Yes	5	12	17	2.7 (0.9–8.3)
City of residence‡				
No	40	25	65	1.0 (Ref.)
Yes	25	41	66	2.7 (1.3–5.3)
Sequelae*				
One limb affected	32	21	53	1.0 (Ref.)
Two limbs affected	19	34	53	2.7 (1.2–5.9)
Three limbs affected	5	5	10	1.5 (0.4–5.9)
Four limbs affected	9	6	15	1.0 (0.3–3.2)
Time of functional recovery (years)				
$> 4$	28	18	46	1.0 (Ref.)
$\leq 4$	34	46	80	2.1 (1.0–4.4)
Time of functional stability (years)				
15–25	15	12	27	1.0 (Ref.)
26–40	34	41	75	1.5 (0.6–3.6)
41–53	13	11	24	1.1 (0.3–3.2)

\*At the time of post-polio syndrome diagnosis.

†During the acute phase.

‡Refers to cities with access to more advanced medical assistance (capitals) and university medical centers during the poliomyelitis acute phase.

Severe refers to patients with post-polio syndrome with an apnea/hypopnea index of  $\geq 15$  events per hour or patients with residual sequelae who, after the new weakness, needed to use a cane, crutches, orthosis, walker, wheelchair or non-invasive mechanical ventilation apparatus; OR, odds ratio.

consider new weakness a criterion, can explain the variations seen (23).

The proportion of severe cases requiring assistance to walk or wheelchairs is similar to that found in the literature (11).

Although the prevalence of sleep apnea was markedly higher among patients with PPS evaluated in the present study than in the general

**Table 4** Final logistic regression model of the factors associated with the severe forms of post-polio syndrome. Neuromuscular Disease Outpatient Clinic at UNI-FESP (Federal University of São Paulo)/EPM (School of Medicine of São Paulo), 2003–2006.

Characteristic	Adjusted OR (95% CI)	P-value*
City of residence <sup>†</sup>		<0.05
No	1.0 (Ref.)	
Yes	2.5 (1.1–5.6)	
Poliomyelitis sequelae (in affected limbs)		<0.05
One	1.0 (Ref.)	
Two	3.6 (1.5–8.7)	
Three	1.8 (0.4–8.3)	
Four	1.7 (0.5–6.5)	
Maximum functional recovery (in years)		<0.001
>4	1.0 (Ref.)	
≤4	2.8 (1.2–6.7)	
Age bracket <sup>‡</sup> (months)		>0.05
<24	1.0 (Ref.)	
≥24	1.8 (0.8–4.2)	
Gender		>0.05
Male	1.0 (Ref.)	
Female	1.8 (0.7–3.6)	

Analysis of residuals using the Hosmer–Lemeshow good-of-fit test ( $P = 0.45$ ). OR, odds ratio.

\*Likelihood ratio test.

<sup>†</sup>Refers to cities with access to more advanced medical assistance (capitals) and university medical centers, during poliomyelitis acute phase.

<sup>‡</sup>During the acute phase.

population (25), it was in accordance with the literature, as was the predominance of the obstructive form of PPS (26, 27), which frequently results in the need for non-invasive ventilation during sleep. Perhaps the higher frequency of obstructive sleep apnea in patients with PPS is due to pharyngeal weakness and greater musculoskeletal deformities caused by scoliosis and emphysema (17).

In the bivariate analysis, we found a strong association between PPS severity and having had 15 and more years of schooling at the time of diagnosis. We hypothesize that these patients had greater access to information, which increased the likelihood that they would seek assistance.

We also found a weak association between PPS severity and the period of functional stability among patients from 26 to 40 years of age, which differs from the results of Ramlow et al. (19), who found a strong association in the period of 30–34 years. This discrepancy can be attributed to the different methodology of study.

The following factors were shown to be associated with the severity of PPS regardless of the other exposures: a period of functional recovery of ≤4 years, permanent damage in two limbs and access to more advanced medical assistance during the acute phase of polio.

Ramlow et al. (19) reported that neuromuscular events occurring between the acute and recovery phases of polio constitute factors associated with

PPS. It is plausible that those same factors are associated with the severity of the disease. During the functional recovery period, re-innervation occurs and the motor neurons that were not totally destroyed by the disease regain their function. In addition, there is an increase in muscle strength, which, in many patients, is attributed to continuous and excessive exercise with hypertrophy of the muscle fiber in the remaining motor units (28). This process is accepted as associated with PPS, according to the muscle overuse theory (29). Depending on the degree of exposure, those same factors might be associated with the severe forms of the disease.

The association between permanent damage in two limbs and PPS might be explained by the overuse of muscles that might have been more often exposed to rehabilitation therapies, daily exercise and a more dynamic lifestyle (29). The association between residence in a city with higher access to medical assistance and the severity of PPS, with access to rehabilitation therapies after the acute phase being considered by proxy (surrogate), confers biological plausibility upon the overuse of muscles theory (29).

Certain limitations of the present study should be taken into consideration when interpreting the results obtained. The study population comprised patients who spontaneously sought medical assistance. Therefore, inferences cannot be made about all patients with PPS. In addition, the losses were not homogeneous, males and patients who had been over 4 years of age at the time of the acute phase of polio were under-represented, which might underestimate the associations related to those variables. Furthermore, the study population did not include patients with the bulbar or non-paralytic forms of acute polio; this fact could have introduced biases resulting from the exclusion of the more severe and less severe forms of polio. The recall bias was also present, as the patients were extremely young at the time of the acute phase of polio.

Finally, the results reported in this study, highlighting the high proportions of severe and disabling forms of PPS, should alert Brazilian health professionals, and as well health professionals in all developing countries, of the need to carefully screen for PPS in all patients with a history of poliomyelitis and be aware of the implications of muscle overuse in the maximum functional and neurological recovery periods.

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**Authors' contributions**

Mônica Tilli Reis Pessoa Conde conceived the study, participated in its design, collected the data, planned the analysis, helped in clinical investigation and led the drafting of the manuscript. Acary Souza Bulle Oliveira participated in designing the study, the clinical investigation and the drafting of the manuscript. Abrahão Augusto Juvinião Quadros participated in the clinical investigation and the drafting of the manuscript. Gustavo Antonio Moreira conducted the polysomnography tests and collected the polysomnography data. Helga Cristina Almeida Silva participated in designing the study and the clinical investigation. Roberto Dias Batista Pereira participated in the clinical investigation. Tatiana Mesquita e Silva participated in the clinical investigation. Sergio Tufik participated in conducting the polysomnography tests. Eliseu Alves Waldman conceived the study, participated in its design, planned the analysis and led the drafting of the manuscript.

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