

## Post-Polio Syndrome - Clinical and Demographic Parameters among Poliomyelitis Patients in Jerusalem

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### ABSTRACT

**Introduction:** According to the WHO there are 10-20 million individuals with poliomyelitis worldwide; as they age, some present with late effects of poliomyelitis, which includes Post-Polio Syndrome (PPS). The demographic, medical, and socioeconomic parameters relating to the occurrence of PPS have been studied with various results.

**Objective:** To determine the medical, demographic and socioeconomic parameters associated with the development of Post-Polio Syndrome (PPS) among poliomyelitis patients in Jerusalem.

**Materials and methods:** A case-control study of 194 poliomyelitis patients attending the post-polio clinic in Hadassah Medical center in Jerusalem. Demographic, medical, social, and functional data were recorded using standard and customized questionnaires for the poliomyelitis patient population. PPS was confirmed according to the March of Dime and EFNS criteria and the severity of PPS was determined using the Index of Post-Polio Sequelae score (IPPS).

**Results:** Among 194 poliomyelitis patients screened, 154 (79%) were diagnosed with PPS; among them 78 (51%) were men. Most demographic and clinical parameters were identical between poliomyelitis patients with or without PPS, BMI and lower education levels were the only significant differences between the groups. Poliomyelitis patients with PPS have significantly more difficulties in walking outdoors and in ADL functions ( $P=0.042$  and  $P=0.007$ , respectively).

**Conclusions:** The prevalence of PPS in our population was among the highest reported. Poliomyelitis patients with PPS show significant difficulties in ambulation and in ADL functions in comparison with polio survivors without PPS. These findings promote the need for proper legislation and multi-institutional recognition and a specific, customized rehabilitation programs for poliomyelitis patients that will aim to maintain their function and to prevent further deterioration due to PPS.

### INTRODUCTION

Poliomyelitis was a major public health threat during the beginning of the 20<sup>th</sup> century until the initiation of the vaccination era [1]. At present, according to the WHO, most of the world is “polio free”, except in a few undeveloped countries [2]. However, millions of people, most of whom were children, have been impacted by the disease, which resulted in a variety of disabilities that has affected their mobility and quality of life [3]. Despite their disabilities, many individuals with poliomyelitis were successful

to accomplish many goals and be a productive part of their societies' working places [4]. However, some of those individuals are now starting to present with worsening of their medical condition. These newly developed symptoms are comprised of new muscle weakness, exacerbation of previous weakness, muscle atrophy, cold intolerance, fatigue and more [5-7]. The exacerbation in the clinical status of poliomyelitis patients is known as Post-Polio Syndrome (PPS) and it has been shown to have a deleterious effect on the function and quality of life of the survivors [8-11]. The frequency of PPS is also variable between different societies and places around the world ranging between 30% to 80%, depending on the criteria used for diagnosis in the different studies [12-14].

PPS diagnosis is fundamentally clinical and of exclusion, since no laboratory or electrophysiological tests are available for diagnosis [15]. Several clinical criteria for diagnosing PPS were introduced and revised through the years [16,17]. They mainly included a confirmed history of poliomyelitis infection, partial or complete neurological and functional recovery from the initial episode, a period of at least 15 years of stable clinical status, and then presentation of new symptoms typical for PPS. These symptoms might include new weakness in previously affected or unaffected muscles, muscle or joint pain, or muscle atrophy; importantly, these new symptoms should not be explained by any other medical condition. In the revised criteria for diagnosing PPS, an emphasis was made on new muscle weakness as the most important criteria for diagnosis [18].

The etiology of PPS is still unknown; the leading theory that explains PPS symptoms is that overused anterior horn motor neurons previously affected by the virus become more prone to early aging and thus are dying early. Alternative theories that might explain the symptoms presented in PPS patients are the potential reactivation of the poliovirus by dormant RNA sequences or an autoimmune process that involves the motor neurons. Although many studies have tried to determine the etiology of PPS, no definite answer has been proven, and consequently all treatment attempts based on these theories were unsuccessful [19,20]. There is also disagreement regarding the risk factors leading to PPS and whether its development is related to the history of the primary infection,

the relative disabilities of the survivors, or to other demographic and functional parameters [21].

In Israel, more than 7,000 people contracted poliomyelitis, most of them during the years of the major epidemics, 1949-1956, usually at their childhood [22-24]. In a recent Israeli census of all poliomyelitis patients held following the 2007 legislation of the Polio Victims Compensation Law, more than 2,500 polio survivors were identified [25]. The epidemiology as well as the parameters associated with the occurrence of PPS in Israel is currently unknown.

The main purpose of this study is to determine the medical, demographic and socioeconomic parameters associated with the development of PPS among poliomyelitis patients in Jerusalem and its surrounding area by comparing these parameters in poliomyelitis patients with and without PPS. Our conclusions and findings may have generalized implications in order to develop more strategies to maintain poliomyelitis patients' physical abilities and functions and to prevent further possible deterioration due to PPS.

## MATERIAL AND METHODS

### Participants

This study is a cross-sectional study that includes 194 polio patients who attended the post-polio clinic in the Physical Medicine and Rehabilitation Department in Hadassah Mount Scopus Medical Center in Jerusalem, Israel. The study was approved by the ethical committee of Hadassah Medical Center. The post-polio clinic in Hadassah Mount Scopus Medical Center opened in 1997. Between the years 2010 and 2012, 209 poliomyelitis patients who attended the clinic were eligible to participate in the study; 14 patients refused or were unavailable, and 194 patients were enrolled. Each participant was evaluated and interviewed by a rehabilitation physician experienced with caring for poliomyelitis patients. An hour-long interview was conducted either in the clinic (92%), the patient's home (5%), or over the phone (3%).

### Survey questionnaire

The demographic, medical, social, and functional data of the poliomyelitis patients were evaluated using a questionnaire similar to the corresponding sections of the National Health Surveys conducted by the Israel Central Bureau of Statistics in 2003/2004 as part of the World Health Organization World Mental Health Composite International Diagnostic Interview

(WHO WMH-CIDI) [26]. All questionnaires were translated to Hebrew and Arabic and validated in the general Israeli population. Demographic data included age, gender, ethnic origin, and place of birth, and socioeconomic data included marital status, having children, level of education, and occupation status. In the self-assessment health questionnaire, the patients were asked to assess their physical, emotional or general state by five options: excellent, very good, good, fair, and poor. Self-reported questionnaire was used to identify difficulties in performing daily tasks (ADL). The ADL questionnaire evaluated independence in bathing-showering, dressing, eating, and functional mobility. Functional mobility questionnaire assessed independence in bed mobility, sit-to-stand and transfer mobility, and indoor and outdoor walking. The functional level was ranked according to five grades: complete independence, independence with difficulties, independence with assistive aid, needs person assistance, fully dependent. The severity of poliomyelitis sequelae was evaluated by the Index of Post-Polio Sequelae score (IPPS), a 12-item scale which focuses on sequelae frequency, has been used to report on poliomyelitis patients across numerous studies [27] and was validated in a previous study [28]. In addition, the history and extent of the poliomyelitis infection was evaluated by using a specific questionnaire, which included: age at which poliomyelitis first presented, body system(s) including need for respiratory support, number of limbs involved, and the usage of walking aids and/or wheelchair. Data about possible comorbidities was obtained using a questionnaire that included questions regarding possible heart diseases, hypertension, diabetes mellitus, chronic back or neck pain, and sleep disorders.

### Diagnosis of PPS

The diagnosis of PPS was made according to the March of Dimes and European Federation of Neurological Societies' (EFNS) diagnostic criteria [16,17] and was based on the following: (1) confirmed history of poliomyelitis; (2) a period of partial or fairly complete function; (3) gradual or abrupt onset of new neurogenic weakness with or without other co-existing symptoms such as muscle fatigue, new muscle atrophy, muscle and joint pain, breathing or swallowing problems, and sleep disorders and cold intolerance; and (4) no other medical diagnosis that explains the above symptoms.

### Statistics

Descriptive statistics were calculated for continuous variables: mean, standard deviation, and range. Difference in continuous variables was evaluated by t-test. Percentages and rates were calculated for the categorical variables and differences were assessed by the chi-square test. Differences between poliomyelitis patients with or without PPS were calculated using one tail t-test.  $P < 0.05$  was considered as significant.

## RESULTS

### Demographic parameter of all poliomyelitis patients in Jerusalem and its surrounding area

194 poliomyelitis patients participated in the study; The mean age was  $57.6 \pm 10.5$  (32-85), 53% were men, 75% were Jews and 25% were Arabs. 73% were married, 84% had children. The education level of the studied sample included 28% patients with 0-11 years of education, 34% with 12-14 years of education, and 38.3 % with more than 15 years. The mean year of education in the group was  $13.1 \pm 5.2$  years. 37.5 % of polio survivors were still employed. 154 of the 194 polio patients fulfill the EFNS criteria for the diagnosis of PPS establishing a high percentage of 79% for PPS in this population.

### Comparison of poliomyelitis patients with and without PPS: demographics and comorbidities

No differences were found between poliomyelitis patients with and without PPS in most of the demographic parameters including gender, ethnicity and place of birth (Table 1).

Table 1: Comparison of demographic data of poliomyelitis patients with (PPS) and without post-polio syndrome (No PPS).

Demographic Parameters	PPS (N= 154)	No PPS (N= 40)	*p value
Age	57.53 $\pm$ 10.5	57.05 $\pm$ 11.1	0.161
Male (%)	78 (51 %)	25 (62.5 %)	0.18
Israeli born (%)	111 (74 %)	28 (74 %)	0.98
Jewish (%)	111 (77 %)	26 (65 %)	0.1
Married (%)	107 (70 %)	33 (85 %)	0.073
Having children (%)	126 (83 %)	34 (85 %)	0.81
High Education (%) > 15 years	49 (33 %)	23 (57.5 %)	0.005
Employment (%)	53 (35 %)	19 (47.5 %)	0.14

A slightly higher number of poliomyelitis patients without PPS was married (85% vs 70% in the PPS group,  $p=0.073$ ) and

was more likely to be employed, however, not to a significantly different degree (35% vs 47.5%,  $p=-0.14$ ). When comparing BMI and education between the two groups, significant differences were found. Poliomyelitis patients without PPS had a significantly higher level of education compared with patients with PPS (57.5% vs 33%,  $p=0.005$ ). Further, compared with patients without PPS, poliomyelitis patients with PPS had significantly higher BMI (28.2 vs 26.2,  $p=0.013$ ) and a higher percentage were obese (BMI  $\geq 30$ , 30% vs 16%,  $p=0.08$ ) (Table 2). Comorbidities such as cardiovascular diseases, hypertension, and diabetes mellitus were not noted to be statistically different between the two populations. Also, there was no difference in the frequency of performing physical exercise between the two groups.

**Table 2: Comparison between poliomyelitis patients with (PPS) and without (No PPS) post-polio syndrome: comorbidities and vascular risk factors.**

Clinical Parameters	PPS N= 154	No PPS N= 40	P value
Mean BMI	28.2 $\pm$ 6.1	26.2 $\pm$ 3.9	<b>0.013</b>
BMI $\geq 30$ (%)	44 (30 %)	6 (16 %)	0.08
Exercise (%)	49 (47 %)	19 (50 %)	0.72
Cardiovascular Diseases (%)	65 (42 %)	14 (35 %)	0.408
Hypertension (%)	69 (45 %)	17 (42.5 %)	0.77
Diabetes (%)	44 (29 %)	8 (20 %)	0.27

### Comparison of poliomyelitis patients with and without PPS: poliomyelitis history, severity parameters and functional disabilities

When comparing poliomyelitis patients with or without PPS, we studied the relation between the history of poliomyelitis infection, which included the age of symptoms onset, the number of limbs involved, respiratory involvement, presence of scoliosis, and the occurrence of PPS (Table 3). Neither age nor the number of limbs involved was found to be related to having PPS. In contrast, respiratory support and the presence of scoliosis were found to be risk factors to the occurrence of PPS. The only significant difference in functional severity comparing poliomyelitis patients with and without PPS was that the former group used wheelchair much more. The total IPPS score of poliomyelitis patients with PPS was significantly higher than those without PPS (2.28  $\pm$  0.73 vs 1.55  $\pm$  0.85,  $p<0.001$ ). Similar results were apparent in IPPS's sub-scores of pain and atrophy but not with the bulbar sub-score.

Poliomyelitis patients with PPS were observed to have more difficulties in ambulation and ADL functions, compared with patients without PPS (Table 4). This includes significantly more difficulties in walking outdoors, standing up, moving outside of bed, bathing, and dressing. There was not statistical difference between patients with or without PPS in indoors walking.

**Table 3: Comparison between poliomyelitis patients with (PPS) and without (No PPS) post-polio syndrome: history and severity of poliomyelitis involvement.**

Poliomyelitis history and severity parameters	PPS (N=154)	No PPS (N=40)	P value
Poliomyelitis contraction age, years	2.51 $\pm$ 3.12	2.08 $\pm$ 2.31	0.46
Number of involved limbs: 1 / >1	87 (56.9%) 66 (43.1%)	25 (62.5%) 15 (37.5%)	0.72
Respiratory support	45 (30.4%)	3 (7.9%)	0.005
Scoliosis	82 (53.6%)	13 (34.2%)	0.032
Using walking aids	79 (51.3%)	20 (50%)	0.88
Using orthoses	89 (57.8%)	24 (60%)	0.80
Using wheelchair	61 (39.9%)	9 (22.5%)	0.042
Wheelchair bound	33 (21.4%)	5 (12.5%)	0.20
Motorized wheelchair	24 (15.6%)	3 (7.5%)	0.19

## DISCUSSION

According to this study, 79% of poliomyelitis patients, in Jerusalem and its surrounding area, have post-polio syndrome. Having lower education and higher BMI, were the only demographic risk factors associated with the development of PPS. Respiratory involvement during the primary poliovirus infection and having scoliosis were also related to higher prevalence of PPS. On the other hand, the age at which the poliovirus infection happened, gender, and the number of limbs involved was not related to the development of PPS. Poliomyelitis patients with PPS had significantly more difficulty walking in the outdoors and in ADL function and used wheelchair more frequently as compared with patients without PPS. The prevalence of PPS remains unclear. Since PPS is a diagnosis of exclusion, a comprehensive clinical evaluation with

an appropriate investigation is necessary in order to establish the diagnosis for PPS [15]. Among poliomyelitis patients, the reported prevalence of PPS ranges between 15% to 80%. This variability is largely related to differences in the population studied, the specific criteria for diagnosing PPS used in each study, and the procedures involved in establishing the diagnosis [29-31]. The prevalence of PPS in our population, 79%, was among the highest reported. This relatively high percentage of PPS in our poliomyelitis patient population could be explained by their relatively advanced age and the fact that the majority of poliomyelitis patients were recruited from the Hadassah clinic due to worsening of their symptoms as the result of the appearance of PPS. Similarly, in a Swedish study of 133 poliomyelitis patients, 86% had a new or worsening muscle weakness and fulfilled the criteria of PPS [32] and in a Japanese study out of 241 poliomyelitis patients, 76.3% met the criteria of PPS [33]. Another possible explanation is the fact that our population has a relatively older age as compared to other studies; the natural overlap between the presentation of normal aging and the presentation of PPS symptoms might explain the higher PPS rates in our study.

difference did not reach statistical significance, due to the small number of non-PPS patients in our cohort. In our sample, the non-PPS group had attained a higher level of education than the PPS group, which is similar to the education levels in an Italian study of 155 patients [14], but different from other studies conducted in Korea and Italy [14,30]. The inverse relationship between level of education and the likelihood that a patient will suffer from PPS is likely due to the higher socio-economic conditions associated with having more education, e.g. better access to quality healthcare, better sources of physical exercise and rehabilitation assistance, and less strenuous physical activity required by the individual's occupation. Similar to other studies, we found a greater prevalence of obesity, as measured by BMI above 30, among the PPS patients compared with patients without PPS [34,35]. Higher BMI could be a result of the sedentary lifestyle caused by the symptoms of PPS, such as weakness, fatigue, and pain; but, conversely, it could be one of the risk factors leading to PPS. Both lower education and obesity, which lead to lower functional abilities, may contribute to the lower employment rate found in PPS patients.

In our previous study, as well as in others, compared with the general population, individuals with poliomyelitis had higher rates of vascular comorbidities [36-39]. However, no difference was noted between those with PPS and without PPS with regard to the presence of these comorbidities. This finding is similar to the study of Bertolasy et al., [14] where no difference was found in the occurrence of cardiovascular diseases between PPS and non-PPS group. In contrast, Ragonese et al. found a significant correlation between the occurrence of other diseases and PPS [14]; however, no disease was specified in their study.

Regarding mobility, in our study, compared with poliomyelitis patients without PPS, 50% of poliomyelitis patients with PPS were able to walk without orthosis or walking aids indoors and 37.3% outdoors, compared with 60% and 55%, respectively, in the non-PPS group. These percentages were similar to those identified by Bang et al [30]; however, Italian PPS patients were much more limited in their ability to walk [14]. In this study, as expected, poliomyelitis patients with PPS needed more support in ADL function such as washing and dressing as compared to patients without PPS. Similar results were noted in

Table 4: Comparison between poliomyelitis patients with (PPS) and without (No PPS) post-polio syndrome regarding present disabilities in ambulation and ADL functions.

	PPS N= 154	No PPS N= 40	P value
<b>Mobility Status</b>			
<u>Walking outdoors. (%)</u>			
Independent	37.3%	55%	<b>0.014</b>
**Dependent	41.8%	35%	
Unable	20.9%	10%	
<u>Walking indoors. (%)</u>			
Independent	49.7%	60%	<b>0.042</b>
**Dependent	35.3%	32.5%	
Unable	15%	7.5%	
<b>Activities of Daily Living (ADL)</b>			
<u>Washing. (%)</u>			
Independent	32.7%	57.5%	<b>0.014</b>
Independent with difficulties	48.4%	27.5%	
Fully dependent	19%	15%	
<u>Dressing. (%)</u>			
Independent	34.6%	70%	<b>0.000</b>
Independent with difficulties	48.4%	15%	
Fully dependent	17%	15%	

In some studies, women were affected more with symptoms of PPS [14,30]; in our study, there were 49% women in the PPS group as compared to 37.5% in the non-PPS group, but this

a Slovenian study of 100 poliomyelitis patients, among whom 69% were diagnosed with PPS [40]. A correlation was not identified between the age of poliomyelitis infection and the number of limbs initially involved in the disease and the occurrence of PPS. The only factors related to the acute infection found to be significantly correlated with PPS were respiratory support and scoliosis. Among poliomyelitis patients with PPS, 30.4% needed respiratory support during the initial infection as compared to only 7.9% in the non-PPS group ( $p=0.005$ ). Regarding the severity of polio symptoms, the total IPPS score was significantly higher among the patients with PPS, emphasizing the more severe involvement of poliomyelitis sequelae [27,28]. The presence of scoliosis increased the risk for having PPS; this might be explained by the limitation scoliosis has on respiratory functions and mobility [41]. Several studies reported an association between disease severity, age of poliomyelitis onset and risk for PPS [5,29,42]. Ragonese et al. [14] also did not find correlation between PPS and number of muscles involved; however, they found that the risk to develop PPS was higher among those who were affected before they were 1 year old. Similar to our findings, others did not find a correlation between PPS and age of primary infection or other symptoms of the primary infections [12,43]. These differences may be explained by methodological differences between the studies as well as differences between the populations and the medical systems in different countries. In addition, it is possible that the association with age at onset, as well as other factors linked to the acute phase of polio, may be false resulting from inaccurate data due to the length of follow-up.

As no curative treatment is available for PPS, rehabilitation management is considered the mainstay of treatment [20,44,45]. A wide range of multi-disciplinary team treatments are recommended, including exercise, diet management, patient education, assistive technology, and lifestyle modifications. Although some uncontrolled studies have shown that strength training, aerobic exercise and aquatic therapy may increase functional capacities in people with PPS, a Cochrane review concluded that there is insufficient evidence of effectiveness of non-pharmacological interventions [20]. Lifestyle changes including pacing of activities, taking resting intervals and reducing weight have been proposed to relieve

symptoms of PPS [46]. As shown in our study and by others, the general health of poliomyelitis patients deteriorated while aging and they need more assistant in activity of daily living especially those who develop PPS. Therefore, the health authorities should promote a specific integrated program including proper legislation, social support and generalized health promoting education to maintain poliomyelitis patients' physical abilities and functions and to prevent further possible deterioration due to PPS.

#### **Limitation**

This study has several limitations: the population sample for this study was from the same post-polio clinic and resides in the same geographical area. Therefore, the population sample might not be a true representation of the general poliomyelitis population in Israel. The number of PPS patients was higher compared with patients without PPS, by the nature of the former group seeking more medical attention. In addition, poliomyelitis patients who attend specialized post-polio clinics present with more severe symptoms and have a higher rate of PPS compared with the general Israeli poliomyelitis patients who might not seek medical attention on a regular basis [47]. Since the data collected is based on self-administrated questioners, the nature of filling these questioners might also pose a limitation.

#### **CONCLUSIONS**

The prevalence of PPS in our poliomyelitis patient population was among the highest reported in the medical literature. Poliomyelitis patients with PPS show significant difficulties in ambulation and in ADL functions compared with poliomyelitis patients without PPS and with the general population. These findings promote the need for proper legislation and multi-institutional recognition and a specific, customized rehabilitation programs for poliomyelitis patients in order to maintain their physical abilities and functions and to prevent further possible deterioration due to PPS.

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## REFERENCES

- Halstead LS. (2011). A brief history of postpolio syndrome in the United States. *Arch Phys Med Rehabil.* 92: 1344-1349.
- Global polio eradication initiative strategic plan. (2004). *MMWR Morb Mortal Wkly Rep.*
- Centers for Disease Control and Prevention (CDC). (2004). Global Polio Eradication Initiative Strategic Plan, 2004. *MMWR Morb Mortal Wkly Rep.* 53: 107-108.
- Grimby G, Jönsson AL. (1994). Disability in poliomyelitis sequelae. *Phys Ther.* 74: 415-424.
- Farbu E, Rekand T, Aarli JA, Gilhus NE. (2001). Polio survivors--well educated and hard working. *J Neurol.* 248: 500-505.
- Dalakas MC, Elder G, Hallett M, Ravits J, Baker M, et al. (1986). A long-term follow-up study of patients with post-poliomyelitis neuromuscular symptoms. *N Engl J Med.* 314: 959-963.
- Trojan DA, Cashman NR. (2005). Post-poliomyelitis syndrome. *Muscle Nerve.* 31: 6-19.
- Li Hi Shing S, Chipika RH, Finegan E, Murray D, Hardiman O, et al. (2019). Post-polio Syndrome: More Than Just a Lower Motor Neuron Disease. *Front. Neurol.* 10: 773.
- Ahstrom G, Karlsson U. (2000). Disability and quality of life in individuals with postpolio syndrome. *Disabil Rehabil.* 22: 416-422.
- Yang EJ, Lee SY, Kim K, Jung SH, Jang SN, et al. (2015). Factors Associated with Reduced Quality of Life in Polio Survivors in Korea. *PLoS One.* 10: e0130448.
- Bickerstaffe A, Beelen A, Nollet F. (2015). Change in physical mobility over 10 years in post-polio syndrome. *Neuromuscul Disord.* 25: 225-30.
- Garip Y, Eser F, Bodur H, Baskan B, Sivas F, et al. (2017). Health related quality of life in Turkish polio survivors: impact of post-polio on the health related quality of life in terms of functional status, severity of pain, fatigue, and social, and emotional functioning. *Rev Bras Reumatol Engl Ed.* 57: 1-7.
- Ramlow J, Alexander M, LaPorte R, Kaufmann C, Kuller L. (1992). Epidemiology of the post-polio syndrome. *Am J Epidemiol.* 136: 769-786.
- Takemura J, Saeki S, Hachisuka K, Aritome K. (2004). Prevalence of post-polio syndrome based on a cross-sectional Survey in Kitakyushu, Japan. *J Rehabil Med.* 36: 1-3.
- Ragonese P, Fierro B, Salemi G, Randisi G, Buffa D, et al. (2005). Prevalence and risk factors of post-polio syndrome in a cohort of polio survivors. *Journal of the Neurological Sciences.* 236: 31-35.
- Lo JK, Robinson LR. (2018). Postpolio syndrome and the late effects of poliomyelitis. Part 1. Pathogenesis, biomechanical considerations, diagnosis, and investigations. *Muscle Nerve.* 58: 751-759.
- March of Dimes Foundation. (2001). Post-polio syndrome: identifying best practices in diagnosis & care. White Plains, NY: March of Dime.
- Farbu E, Gilhus NE, Barnes MP, Borg K, de Visser M, et al. (2006). EFNS guideline on diagnosis and management of post-polio syndrome. Report of an EFNS task force. *Eur J Neurol.* 13: 795-801.
- Gonzalez H, Olsson T, Borg K. (2010). Management of postpolio syndrome. *Lancet Neurol.* 9: 634-642.
- Lo JK, Robinson LR. (2018). Post-polio syndrome and the late effects of poliomyelitis: part 2. Treatment, management, and prognosis. *Muscle Nerve.* 58: 760-769.
- Koopman FS, Beelen A, Gilhus NE, de Visser M, Nollet F. (2015). Treatment for Postpolio syndrome. *Cochrane Database of Systematic Reviews.* 18: CD007818.
- Trojan DA, Cashman NR, Shapiro S, Tansey CM, Esdaile J, et al. (1994). Predictive factors for post-poliomyelitis syndrome. *Arch Phys Med Rehabil.* 75: 770-777.
- Swartz TA. (2008). The Epidemiology of Polio in Israel. Israel Center for Disease Control (ICDC), Ministry of Health. Dyonon Pub Ltd.
- Adler E, Eliakim C, Magora A. (1955). Poliomyelitis in Jerusalem in 1953. *Acta Med Orient.* 14: 147-163.
- Slater PE, Handsheer R, (1989). Polio in Israel. *Nature.* 338: 110.

26. Polio survivors' report. (2008). Selected characteristics. National Insurance Institution, Research and Planning Administration, Jerusalem.
27. <https://www.hcp.med.harvard.edu/wmh/index.php>
28. Kalpakjian CZ, Toussaint LL, Klipp DA, Forchheimer MB. (2005). Development and factor analysis of an index of post-polio sequelae. *Disabil Rehabil.* 27: 1225-1233.
29. Schwartz I, Gartsman I, Adler B, Friedlander Y, Manor O, et al. (2014). The Association between Post-Polio Symptoms as measured by the Index of Post-Polio Sequelae and Self-Reported Functional Status. *J Neurol Science.* 345: 87-91.
30. Wekre LL, Stanghelle JK, Lobben B, Oéyhaugen S. (1998). The Norwegian Polio Study 1994: a nation-wide survey of problems in long-standing poliomyelitis. *Spinal Cord.* 36: 280-284.
31. Bang H, Suh JH, Lee SY, Kim K, Yang EJ, et al. (2014). Post-polio syndrome and risk factors in Korean polio survivors: a baseline survey by telephone interview. *Ann Rehabil Med.* 38: 637-647.
32. Yelnik AP, Andriantsifanetra C, Bradai N, Sportouch P, Beaudreuil J, et al. (2013). Poliomyelitis sequels in France and the clinical and social needs of survivors: a retrospective study of 200 patients. *Ann Phys Rehabil Med.* 56: 542-50.
33. Thorén-Jönsson AL, Grimby G. (2001). Ability and perceived difficulty in daily activities in people with poliomyelitis sequelae. *J Rehabil Med.* 33: 4-11.
34. Bertolasi L, Danese A, Monaco S, Turri M, Borg K, et al. (2016). Polio Patients in Northern Italy, a 50 Year Follow-up. *Open Neurol J.* 10: 77-82.
35. Chang KH, Lai CH, Chen SC, Hsiao WT, Liou TH, et al. (2011). Body composition assessment in Taiwanese individuals with poliomyelitis. *Arch Phys Med Rehabil.* 92: 1092-1097.
36. Bargieri JV, Quadros AA, Pereira RD, Oliveira AJ, Lazaretti-Castro M, et al. (2008). Basal metabolic rate and body composition in patients with post-polio syndrome. *Ann Nutr Metab.* 53: 199-204.
37. Schwartz I, Gartsman I, Adler B, Friedlander Y, Manor O, et al. (2018). High Prevalence of Cardiovascular Comorbidity and Chronic Pain in Polio Survivors as Compared to the General Population. *Phys Med Rehabil Int.* 5: 1138.
38. McNalley TE, Yorkston KM, Jensen MP, Truitt AR, Schomer KG, et al. (2015). Review of secondary health conditions in postpolio syndrome: prevalence and effects of aging. *Am J Phys Med Rehabil.* 94: 139-145.
39. Wu CH, Liou TH, Chen HH, Sun TY, Chen KH, et al. (2012). Stroke risk in poliomyelitis survivors: a nationwide population-based study. *Arch Phys Med Rehabil.* 93: 2184-2188.
40. Gawne AC, Wells KR, Wilson KS. (2003). Cardiac risk factors in polio survivors. *Arch Phys Med Rehabil.* 84: 694-696.
41. Burger H, Marincek C. (2000). The influence of post-polio syndrome on independence and life satisfaction. *Disabil Rehabil.* 22: 318-322.
42. Shoseyov D, Cohen-Kaufman T, Schwartz I, Portnoy S. (2017). Comparison of activity and fatigue of the respiratory muscles and pulmonary characteristics between post-polio patients and controls: A pilot study. *PLoS One.* 12: e0182036.
43. Ivanyi B, Nollet F, Redekop WK, de Haan R, Wohlgemuth M, et al. (1999). Late onset polio sequelae: disabilities and handicaps in a population-based cohort of the 1956 poliomyelitis outbreak in The Netherlands. *Arch Phys Med Rehabil.* 80: 687-690.
44. Kay L, Nielsen NM, Wanscher B, Jennum P. (2018). Neurological Symptoms in Danes with a History of Poliomyelitis: Lifelong Follow-Up of Late Symptoms, their Association with Initial Symptoms of Polio, and Presence of Postpolio Syndrome. *Eur Neurol.* 80: 295-303.
45. Atwal A, Duncan H, Queally C, Cedar SH, et al. (2019). Polio survivors perceptions of a multi-disciplinary rehabilitation programme. *Disabil Rehabil.* 41: 150-157.
46. Tiffreau V, Rapin A, Serafi R, Percebois-Macadré L, Supper C, et al. (2010). Post-polio syndrome and rehabilitation. *Ann Phys Rehabil Med.* 53: 42-50.
47. Lexell EM, Lexell J, Larsson-Lund M. (2016). The rehabilitation plan can support clients' active engagement and facilitate the process of change - experiences from people with late effects of polio participating in a rehabilitation programme. *Disabil Rehabil.* 38: 329-336.