Therapeutic Aspects of Post-Polio Syndrome: A Comprehensive Scoping Review

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Abstract: ***Background**: Post-Polio Syndrome (PPS) is a condition that affects polio survivors years after their initial recovery, manifesting in new symptoms such as muscle weakness, fatigue, and pain. Despite its prevalence, comprehensive reviews of therapeutic approaches for managing PPS are limited. **Objective**: This scoping review aims to explore and summarize the current therapeutic aspects of PPS, including pharmacological treatments, physical therapies, and other interventions, to identify gaps in knowledge and areas for future research. **Methods**: A systematic search was conducted across multiple databases, including PubMed, Scopus, MeSH, PEDro and Cochrane Library, focusing on studies published between 2020 and 2024. Articles were screened for relevance based on predefined inclusion criteria, and data were extracted on therapeutic interventions, outcomes, and patient experiences. **Results**: A total of 64 studies met the inclusion criteria. The review found that physical therapy and exercise programs were the most commonly reported interventions, with evidence supporting their role in improving function and quality of life. Pharmacological treatments, including pain management and fatigue reduction, showed variable efficacy. Emerging therapies, such as neuromuscular stimulation and psychological support, were less studied but indicated promising results. **Conclusion**: The therapeutic landscape for PPS is diverse, with physical therapy and exercise being the most supported interventions. However, there is a need for more high-quality research to evaluate the effectiveness of pharmacological treatments and innovative therapies. Future studies should focus on longitudinal outcomes and personalized treatment approaches to better address the complex needs of PPS patients.***

Keywords: Post-Polio Syndrome, Therapeutic Interventions, Physical Therapy, Pharmacological Treatments, Scoping Review

1. Introduction

Post-Polio Syndrome (PPS) is a long-term condition that affects individuals who have previously contracted poliomyelitis (a viral infection primarily impacting the nervous system).

The Poliovirus targets the motorneurons of the anterior horn cells of the spinal cord or the brainstem, acute anterior poliomyelitis leads to asymmetric muscular paralysis, with varying degrees of severity, reaching its peak in 48 hours and sometimes associated to a respiratory and bulbar affection.[1]

The major clinical features of PPS are new muscle weakness, new atrophy, muscle and joint pain, increased muscular fatigability, general fatigue, and cold intolerance[2]

PPS is classified as a motor neuronopathy, as its clinical and histological aspects are closely related to lower motor neuron dysfunction. It is estimated that 70% of the patients who have survived poliomyelitis will develop PPS.[3]

The hallmark criteria for the diagnosis are a confirmed prior history of paralytic poliomyelitis; evidence of residual functional deficits, specifically muscle weakness or atrophy, and signs of denervation on electromyography (EMG); a stable period (usually 15 years or more) after recovery from the acute illness; and "the gradual or sudden onset of progressive and persistent new muscle weakness or abnormal muscle fatiguability (decreased endurance)." Generalized fatigue, muscle or joint pain, cold (and, more rarely, heat) intolerance, and sleep disorders are other frequently reported symptoms, but are not necessary to establish the diagnosis.

Recommendations for the treatment of PPS include muscle strengthening and endurance exercises, isolated or combined, and changes in lifestyle, alternative forms of treatment (thermotherapy, massage therapy, and integrative practices) and activities suitable for the clinical presentation of the individual. In addition to these interventions, re-education and rehabilitation strategies are recommended with the aim of improving balance, functional capacity, and energy conservation.

Rehabilitation is considered the mainstay of management in PPS, with an emphasis on physical therapy. This rehabilitation differs from the approach employed to provide relief during the recovery phase of poliomyelitis. The aim is to reach a functional balance by increasing capacities and reducing demands.

Frequent periods of rest, energy conservation, and work simplification skills are also useful, and general lifestyle modifications including weight control, physical activity, adaptation to assistive devices, and modification of daily activities are advocated to diminish fatigue. Properly fitted orthoses can improve the biomechanical movement pattern and be energy-saving.

Aerobic exercise using the treadmill improves fatigue, functional capacity and quality of life in persons with PPS reviewed studies dealing with exercise therapy for clients with PPS and found evidence for the effectiveness of strengthening or aerobic exercise to be insufficient. Suggested endurance and resistive training to be effective in increasing muscle strength and endurance in subjects with PPS. Noted that clients with PPS who had regular physical activity had fewer symptoms and a higher level of functioning than those who were not often physically active.[5]

2. Methods

Information sources:
Published Case Studies, randomized controlled trials examining Therapeutic aspects of Post-Polio Syndrome. Using a predetermined search strategy, PubMed, Pedro, Google Scholar, and the Physiotherapy Evidence Database (Pedro) were all searched from their inception through the years 2013–2024.

Eligibility criteria:

Inclusion criteria:
Participants included will be:

1) It includes involving post polio syndrome
2) Articles which are written in English.
3) The study includes search stratergy all types of literature which includes Pubmed, Embase, Cochrane, CINAHL, PEDro and MeSH of all types of articles in that outcome measures are used.

Exclusion criteria:
Participants excluded will be:

1) Articles published in other languages.
2) Articles not reporting outcome measures.
3) Discussion /position papers or comments.
4) Poster presentation, abstracts or articles without enough information about the intervention.
5) Articles only reporting the development of technology. The search was not limited by study design or the date of publication.
6) Duplicate articles should be removed.

S No.	Author	Year	Type Of Study	Outcomes
1.	Monalisa pereira motta et.al.[11]	2023	Open Label Study	1. Time Up and Go assessment tool. 2. Instrutherm® manual digital dynamometer (handgrip strength testing) 3. Revised Piper Fatigue Scale.
2.	Eric chun.pu chu et.al.[1]	2023	Case Report	1. NPRS 2. MRC Grading scale 3. World Health Organization Quality of Life (WHOQOL-OLD)
3.	Alberto GARCÍA-SALGADO et.al.[1]	2021	Case Report	1. TSK-11(Tampa scale of Kinesiophobia) 2. FRT 3. 6MWT 4. Modified Borg Scale 5. LLFI(Lower limb functional index) 6. VAS
4.	Erika Christina Gouveia e silva et.al.[3]	2020	Randomized controlled trial	1. Motor Function Measure— 32 (MFM-32) 2. Box and Block Test (BB) 3. Functional Independence Measure (FIM) 4. Functional Reach Assessment (FRA). 5. Fatigue Severity Scale (FSS) 6. Visual Analogue Scale (VAS).
5.	Kary ka wai lam et.al.[1]	2019	Case Report	1. MRC Grading scale 2. Surface EMG (MyoVision®) 3. WHOQOL-BEEF
6.	Carolyn P Da Silva et.al.[2]	2018	Pilot study	1. Pittsburgh sleep quality index (PSQI) 2. MRC grading scale and Hand held Dynamometry 3. Brief Pain Inventory (BPI)
7.	Eric L Voorn et.al.[6]	2016	Randomized controlled trial	1. Submaximal exercise test 2. MRC grading scale 3. Dynamometer (Biodex system 3) 4. Submaximal incremental cycle ergometry tests.

S. No.	Author	Intervention	Conclusion
1.	Monalisa pereira motta et.al.[11]	Radio Electric Asymmetric Conveyer (REAC) Technology and Neuro Psycho Physical Optimization Treatments: **The REAC technology:** The REAC technology is an innovative therapeutic approach that utilizes radio electric fields asymmetrically conveyed to promote healing processes and restore physiological balance within the human body. **Neuro Postural Optimization (NPO):** REAC NPO is a non-invasive neuromodulation treatment that focuses on improving postural control and stability by modulating the neurobiological system. NPO recognizes the essential role of the central nervous system (CNS) in maintaining postural stability and movement control. **Neuro Psycho Physical Optimization and Neuro Psycho Physical Optimization Cervical Brachial:** The specific REAC treatments employed in this study NPPO and NPPO-CB represent an advanced neuromodulation treatment that focuses on optimizing human performance by acknowledging the intricate relationship between the nervous system, psychological well-being, and physical body.	Given the data presented, it can be inferred that the intervention through the REAC NPO, NPPOs, and NMO treatments demonstrated positive effects in improving the fatigue index, functional performance of gait, and handgrip strength. Furthermore, the use solely of the NPO protocol proved to be a good therapy for improving the fatigue

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<tr><td></td><td></td><td>Neuromuscular Optimization (NMO): NMO is the term used to encompass a set of therapeutic protocols for neurobiological modulation within the REAC technology aimed at optimizing muscle management, particularly the functional balance between agonist and antagonist muscles, in both pathological and dysfunctional conditions.</td><td>index and functional gait performance.</td></tr>
<tr><td>2.</td><td>Eric chun. pu chu et.al.[1]</td><td>During each visit, the intervention included:
15-minute mechanical cervical traction to reduce the pressure on the nerves;
8-minute cervical and lumbar manual therapy to improve mobility;
8-minute deep muscle massage using a handheld micro-vibrator (Strig®, STRIG Inc., Korea) to relax the hypertonic muscles; and
15-minute isometric core trunk muscle training to strengthen the paraspinal muscles and improve spine posture. The patient was seated in a commercially robotic chair (AllCore360° Core Training System®, AllCore360, GA, USA) for the workout.
Initial treatment sessions were scheduled 3 times a week for the first month, focusing on pain symptoms. Then, the frequency of treatment was reduced to 2 times a week for 2 months, focusing on relieving pain and improving core muscle functions. Afterwards, the patient was seen once a week for 10 months, focusing on correcting both pelvic and spinal postures. The frequency of treatment was further reduced to once a month for 30 months, focusing on monitoring the symptoms, spinal adjustment, and core muscle training. A home stretching program (muscle strengthening, mobility training, and ergonomic recommendations) was also used as an adjunct to care.</td><td>The current study was the first to report INEM among patients with PPS. The suggested multimodal intervention with long-term spinal manual therapy has shown significant improvement in neuromuscular symptoms, the head and global posture, and spinal function.</td></tr>
<tr><td>3.</td><td>Alberto GARCÍA-SALGADO et.al.[1]</td><td>Manual therapy: Accessory physiological mobilizations central and unilateral AP grade I-II Maitland around 2 minutes, 3 sets. Active neural tube sliders for 10 reps, 3 sets.
Therapeutic exercise: Lumbar motor control exercises in supine-prone. 1) Quadruped (Repetitions: 10-12/ Series: 3-4)
2) Sit-to-Stand in chair (Repetitions:10-12/ Series:3-4)
Increase in daily activity: Walk 15-30 minutes.

Strength circuit: 4 sets of 6-8 repetitions at a perceived effort of 6-8 according to the modified Borg scale:
Squat with support
Hip Thrust
Push ups with or without knee support.
Overhead press
Lounge with assistance
Static plank
Cardiorespiratory Circuit: 3 sets of the circuit at 40 seconds per station with 25 secs rest. Perceived effort between 6-8.
Mountain climbers
Knee raise
Walk Semi tandem
Farmer's walk
Conventional deadlift with superband.</td><td>In conclusion, focusing treatment on a biobehavioural paradigm centred on TE and education through telerehabilitation can be a treatment option, as observed in this patient with PPS and musculoskeletal pain, as it can lead to improvements in the medium term on functional and psychological variables.</td></tr>
<tr><td>4.</td><td>Erika Christina Gouveia e silva et.al.[3]</td><td>Participants were randomized into two groups: The Upper Limb Active Exercises group (AEG) and Interactive Videogame Group (IVG). The protocols were developed with the aim of providing similar intensity, frequency, duration, and volume in both groups. The two groups performed two weekly sessions lasting 50 minutes each, totaling 14 sessions.
A 10-minute warm-up was performed at the beginning of all sessions and included active muscle stretching exercises of the cervical and upper limbs. After the warm-up, the participants were referred to the specific group intervention session. Individuals from both groups performed the interventions sitting in a chair with their feet resting on the floor.
Interactive Video Game Group: IVG participants were positioned in front of a 32 inch TV placed 1.2 m away and attached to the wall, 1.5 m from the ground. During the familiarization session, the therapist presented the equipment and explained the rules of each game (tennis, golf, boxing, and bowling).Each game was performed with the help of the researcher who corrected the movements and posture of participants. Each game was played for 10 minutes.
Active Exercises Group: The AEG performed similar movements required for playing the four videogames of the IVG. To develop the control group protocol, three researchers analyzed the movements required by the four games, the rest interval between the games, and the total length of each game. This procedure was performed to promote the same motor demand for both groups. The AEG intervention included upper limb active exercises involving shoulder, elbow, and trunk, in blocks of 8 minutes with a 2-minute rest interval between the exercises</td><td>The results showed that upper limb active exercises and interactive videogames provide positive effects on upper limb function, functionality, dexterity, balance, reduced muscle fatigue, and pain in individuals with PPS. The videogames promoted greater effects on dexterity compared with the active exercises. These positive clinical effects support the use of interactive videogames as an alternative to upper limb rehabilitation for PPS.</td></tr>
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5.	Kary ka wai lam et.al.[1]	In the early phase of intervention: • chiropractic modalities • therapeutic ultrasound therapy (three times a week) and • myofascial mobilization ie, Graston® technique (one to two times a week) In the following two months: • spinal adjustments (diversified technique) and • spinal traction were performed two times a week.	This case report describes the effectiveness of manual interventions in assisting our patient in restoring the level of function and alleviating pain.
6.	Carolyn P Da Silva et.al.[2]	Individuals were randomly assigned into one of two intervention groups with one group participating in low intensity WBV 4-week block of eight sessions first (group Lo–Hi), and higher intensity WBV 4-week block of eight sessions, second. The second group participated in both WBV intervention blocks in the reverse order (group Hi–Lo). The low intensity (peak-to-peak amplitude 4.53 mm, 24 Hz, unit of gravity of Earth [g] force 2.21) intervention was provided by the Soloflex (Hillsboro, OR 97124, USA), a relatively small unit that is usable within the home. This force was the Soloflex's lowest setting, labeled "acceleration-load" 0.3g. • Participants started with 1-min standing with vibration on, 1-min sitting with no vibration, with this sequence repeating 10 times for 10 total minutes of vibration per session, gradually increasing to 2-min increments of vibration, 1-min rests, for 20 total minutes. • Fifteen seconds were added to each vibration bout so that each session of 10 bouts increased by 2.5 min until 20-min maximum was attained, if no increased PPS symptoms were reported when asked. • Participants were expected to be able to increase to the goal of 20 min at the fifth session, thereby having sessions five through eight at 20 min. Blood pressure and heart rate were measured before and after each vibration session. Rating of perceived exertion (RPE) was measured after each session.	Preliminary results of this exploratory study indicate WBV to be a safe, tolerable, and feasible form of weight-bearing exercise for people with PPS. Short term changes in pain and gait speed for some individuals are encouraging for polio survivors who have limited methods to exercise. This study has attempted to answer the first big question of a feasibility study, "Can it work?" with "Yes, it can."
7.	Eric L Voorn et.al.[6]	**Usual care:** The participants in the UC and ET group all received UC. UC for PPS could include the use of assistive devices and/or orthoses, physical therapy, and medication use. Participants were not restricted in their activities. **Exercise therapy:** ET lasted 4 months and consisted of (1) a home-based aerobic training program on a bicycle ergometer 3 times weekly and a (2) supervised group training containing muscle strengthening and functional exercises once a week. • Participants were supplied with a bicycle ergometer (Kettler X7, Germany) and logbook with training instructions at their home. In the logbook, participants documented the number and duration of treatment sessions, their perceived exertion on the Borg Scale (range 6–20). • Training intensity was gradually increased from 60% to 70% HRR, and the training duration was gradually increased from 28 to 38 minutes per session. • Sessions were divided into prescribed exercise bouts (increasing from 2 to 13 minutes). The supervised group training consisted of individually tailored strengthening exercises and functional exercises in 1 hour group sessions.	Despite high attendance rates, severely fatigued individuals with PPS did not adhere to a 4-month high intensity home-based aerobic training program on a bicycle ergometer. Although participants instead trained around their AT most of the training period, the program did not result in an increased aerobic capacity, as muscle function nor cardiorespiratory fitness improved.

3. Result

A total of 64 experiment-based Researches were taken into the study related to scope and impact of physiotherapy in PPS. 25 were excluded for not meeting the inclusion criteria and 12 were reported duplicate articles. 12 were not reported outcomes. Hence, a total of 7 studies were included in this review. Out of which 5 has shown better result Strength training combined with manual therapy as compared to other treatment procedures.2 has shown more result in functional improvement in patient with PPS.

4. Discussion

Post-Polio Syndrome (PPS) is a complex, progressive condition that affects individuals who have previously recovered from polio but experience new or worsening symptoms, including muscle weakness, fatigue, and pain. The management of PPS requires a multi-faceted approach to address both the physical and psychological aspects of the condition. Several studies have explored various treatment modalities, and the findings offer promising insights into potential therapeutic strategies.

Monalisa Pereira Motta et al. highlight the potential of neurobiological modulation treatments, including REAC NPO, NPPOs, and NMO, as new strategies for alleviating both the physical and psychological symptoms of PPS. These treatments aim to stimulate neural regeneration and enhance nerve activity, potentially improving both mobility and functional performance. Participants in the study demonstrated significant improvements when comparing initial and follow-up assessments, suggesting that neurobiological modulation could provide a novel therapeutic avenue for patients suffering from the debilitating effects of PPS. This aligns with emerging trends in neuroplasticity research, where neural networks are targeted to restore function, particularly in cases of neurological damage.[3]

Eric Chun-Pu Chu et al.[1] propose that a key factor in recovery from PPS is the ability of unaffected neighboring nerve cells to "sprout" and reconnect to paralyzed muscles. This neuroplasticity concept is critical in understanding how recovery can occur even after long-term paralysis. This process helps bypass damaged or non-functional nerve pathways, potentially restoring some motor function. However, while neuroplasticity is a promising area of study, its role in PPS recovery requires further investigation, especially in terms of the intensity and duration of therapies that might enhance this process.

The study by Alberto García-Salgado et al. explores the growing use of telematic interventions and online assessments for treating PPS, emphasizing their potential as cost-effective tools. These interventions are especially beneficial for patients with limited access to in-person rehabilitation services. However, the study also points out a key limitation: the lack of interpersonal proximity, which can hinder the effectiveness of the treatment. Despite this, telehealth can still play a significant role in increasing patient self-efficacy and adherence to therapeutic exercises, which are essential components of PPS management. The combination of telehealth with more traditional therapies could provide a well-rounded treatment plan that addresses both the logistical and emotional aspects of care.

Erika Christina Gouveia e Silva et al. (3) demonstrated that conventional physical therapy can significantly improve muscle function, balance, and fatigue in individuals with PPS. Specifically, upper limb active exercises and interactive video games were shown to positively impact upper limb motor function. The use of technology in the form of video games offers a creative and engaging way to encourage physical activity, which is crucial for PPS patients who often experience difficulty with motivation and fatigue. This finding supports the idea that a combination of traditional physical therapy and innovative interventions can improve the quality of life for PPS patients by enhancing both motor function and psychological well-being.

Kary Ka Wai Lam et al. (1) emphasize the importance of interdisciplinary care in the management of PPS. The study highlights that conservative treatments, including muscular strengthening, aquatic therapy, and endurance training, play a central role in managing PPS symptoms. Tailored rehabilitation approaches that combine multiple therapeutic modalities show significant benefits in terms of muscular exertion, endurance, and pain relief. This aligns with the growing consensus that holistic and patient-centered care is the best strategy for PPS management. An individualized approach that considers the patient's unique needs and symptoms can result in more effective outcomes.

Carolyn P. Da Silva et al. provide insights into the potential wellness benefits of Whole-Body Vibration (WBV) for muscle health, bone density preservation, pain management, and functional mobility. While walking speed did not significantly differ at baseline, the Hi–Lo group demonstrated significant improvement in walking speed after undergoing higher intensity WBV interventions. This suggests that WBV therapy could be a promising treatment modality for improving functional outcomes in PPS patients, especially those with mobility issues. The low-impact nature of WBV may be particularly beneficial for individuals with PPS, as it allows for muscle strengthening and improved circulation without putting undue stress on the joints. Eric L. Voorn et al. (6) highlighted that while participants in their study exercised at or slightly above their anaerobic threshold (AT) for much of the training period, the findings did not confirm that the exercise program was effective in increasing aerobic capacity in PPS patients. This raises an important issue in PPS rehabilitation: while exercise is an essential part of managing the condition, its direct impact on aerobic fitness in PPS patients remains unclear. Further studies are needed to better understand the optimal intensity and duration of exercise required to improve aerobic capacity and overall functional capacity in this population.

5. Conclusion

The study concludes challenges and uncertainties surrounding the management of Post-Polio Syndrome, physiotherapy emerges as a valuable therapeutic modality with the potential to improve outcomes and enhance the quality of life for affected individuals. By continuing to explore new avenues for research, practice, and collaboration, we can further advance our understanding and management of this debilitating condition.

Scope:
Future studies may explore more advanced therapeutic techniques within physiotherapy, such as virtual reality-assisted rehabilitation, robotics-assisted therapy, or neuromodulation techniques. These innovative approaches could offer new avenues for improving outcomes and enhancing recovery in individuals with delayed polyneuropathy.

There may be a shift towards personalized rehabilitation programs tailored to the specific needs and characteristics of individuals affected by Post-Polio Syndrome. This could involve incorporating patient-specific factors such as severity of symptoms, comorbidities, functional limitations, and psychosocial factors into the design and implementation of physiotherapy interventions.

Future research may increasingly emphasize the importance of multidisciplinary collaboration in managing delayed polyneuropathy. Physiotherapists may work closely with other healthcare professionals such as neurologists, occupational therapists, psychologists, and nutritionists to provide comprehensive care addressing the diverse needs of patients with Post-Polio Syndrome.

There might be a greater focus on long-term follow-up studies to assess the sustained effects of physiotherapy interventions on functional outcomes, quality of life, and prevention of secondary complications in individuals with PPS.

The future scope of physiotherapy in Post-Polio Syndrome is likely to encompass a broader range of interventions, personalized approaches, interdisciplinary collaboration, long-term outcome assessment, and preventive strategies aimed at optimizing patient care and improving clinical outcomes.

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