

Aetiology of Post-Polio Syndrome

The pathological changes that produce the symptoms of post-polio syndrome are not well understood, but several theories have been developed over the years (Table 3).

Table 3: Proposed Aetiologies of PPS⁵

1. Motor unit dysfunction – degenerative changes within motor units
2. Muscle overuse
3. Muscle disuse
4. Loss of motor units with ageing
5. Predisposition to motor neuron degeneration because of glial, vascular, and lymphatic changes caused by acute polio
6. Chronic poliovirus infection or virus reactivation
7. An immune mediated syndrome
8. The effect of growth hormone
9. The combined effects of disuse, overuse, pain, weight gain or other illnesses

These theories will be briefly explained.

Motor Unit Dysfunction – Degenerative Changes Within Motor Units

Theory:

The new weakness and fatigue characteristic of PPS are due to degenerative changes in motor units, particularly loss of terminal axonal sprouts (peripheral disintegration).

Research:

This phenomenon, which occurs during recovery from paralytic polio (i.e. sprouting from surviving motor neurons leading to reinnervation of muscle fibres), is well documented. There is now considerable evidence that suggests that the abnormally enlarged motor units that develop after acute paralytic polio are not indefinitely stable.

Conventional electromyographic observations on post-polio muscles show that muscles which become extremely weak and atrophic have few to no motor unit action potentials (MUAPs), while other muscles, including those that are clinically normal or historically not affected, have large, polyphasic MUAPs.^{17,27} This is expected when one considers the generalised nature of the acute illness. The size of the voluntary motor unit action potentials are increased due to a very successful reinnervating process that results in giant-size motor units.⁵⁶

In a study comparing the size of MUAPs in control subjects and post-polio subjects with and without new weakness, Agre and Rodriquez (1990)¹⁷ found that the size of MUAPs was significantly larger in all post-polio subjects, and that those with new weakness had larger units than those without.

Wiechers and Hubbell (1981)¹⁶ first proposed that the abnormally enlarged motor units that develop after acute paralytic polio are not indefinitely stable, but that terminal axonal sprouts degenerate over time producing denervation of muscle fibres. It is possible that some of these denervated muscle fibres may become reinnervated by sprouts from neighbouring motor neurons, producing a continuous “remodelling” process of the post-polio motor units.

Many researchers now agree that this ongoing denervating and re-reinnervating process stresses the motor neurons, which after a number of years appear to lose their ability to maintain the metabolic demands of all their sprouts. Consequently, there is slow deterioration of some nerve terminals. As axonal sprouts die, some muscle fibres become permanently denervated and the post-polio individual experiences new weakness and other symptoms of neurological dysfunction.^{5,7,56} This process is illustrated in Figure 1 (page 4). Several electrophysiological and muscle biopsy studies have provided further evidence of neuromuscular transmission abnormalities and muscle fibre denervation in post-polio subjects.^{18,28,57}

New weakness in PPS can be explained on the basis of the reduced size of the motor unit when the reinnervation cannot keep pace with the ongoing denervation.⁵⁶ Trojan and Cashman (1997)⁹ hypothesised that if terminal axonal degeneration is the cause of new weakness in PPS, it is likely that there is a period of terminal axonal dysfunction that may precede degeneration by months to years. They believe that muscle fatigue in PPS can be attributed to neuromuscular junction transmission defects.

Muscle Overuse

Theory:

Enlarged motor units supplying post-polio muscles cannot indefinitely maintain the increased metabolic activity needed. As a result, overused motor units eventually degenerate, resulting in slowly increasing weakness and rapid fatiguing of muscles.

Research:

Increased creatinine kinase (CK) levels have been found in symptomatic subjects after polio, but not in equally weak asymptomatic subjects after polio.⁵⁴ Waring and McLaurin (1992)⁵⁸ found CK levels to be significantly correlated with distance of ambulation in post-polio subjects, suggesting that exercise is the cause of elevated CK in this population. Since elevated CK levels can be a marker for muscle injury, the increased CK levels may indicate muscle injury or overuse in post-polio individuals.

Perry, Fontaine and Mulroy (1995)⁵⁹ performed dynamic EMG studies during gait in post-polio subjects and found evidence of overuse in the biceps, gluteus maximus and quadriceps muscles.

Trojan and colleagues found in 1994 that muscle pain (especially that associated with exercise), joint pain, and a recent weight gain, were associated with PPS.⁴⁸ All of these factors can be markers of overuse, providing further evidence for the theory that overuse is a contributing factor to PPS. Numerous clinical studies have shown a correlation between the presence of PPS and a history of severe initial paralysis with a relatively good recovery of useful strength and function.^{48,52,60}

These observations support the theory that weakness and fatigue in PPS results from long-term substitutions for muscular weakness that place increased demands on muscles.

Muscle Disuse

Theory:

Disuse produces both deconditioning and muscle weakness in individuals.⁶¹

Research:

Post-polio subjects have been noted to have short-term increased weakness after a period of decreased activity that is secondary to illness or injury.¹⁵ The role of muscle disuse in the development of long-term weakness, however, is less clear.⁵

Loss of Motor Units with Ageing

Theory:

The natural ageing process depletes remaining anterior horn cells, leading to progressive weakness.

Research:

The normal ageing process is known to involve a gradual loss of motor neurons, but only becomes prominent after the age of 60.⁶² Several studies have failed to show a consistent correlation between the onset of new weakness and chronological age. The most consistent variable is the length of the interval between onset of polio and the appearance of new symptoms. Most subjects develop new weakness 30 to 40 years after their initial infection, and the age of onset of symptoms is variable.⁵ The superimposition of the normal ageing process on the already limited number of motor neurons present after paralytic polio may contribute to the development of PPS.⁷ The current consensus is that while chronological age may contribute to the development of new weakness, it is probably not the primary causative factor.^{5,7,56}

Less Supported Theories

Other theories that have emerged to explain the triggering mechanisms for motor unit degeneration include:

- Predisposition to motor neuron degeneration because of glial, vascular and lymphatic changes caused by acute polio – damage to the glial cells and vascular supply at the time of the acute infection can lead to secondary dysfunction of anterior horn cells.⁶³
- Chronic poliovirus infection or virus reactivation – PPS may be caused by re-exposure to live poliovirus or re-activation of persistent poliovirus in the CNS.^{28,46,64}
- An immune mediated syndrome – an ongoing inflammatory or immune response mechanism may be a precipitating factor in the development of PPS.^{5,65,66}
- The effect of growth hormone – ageing of the hypothalamus growth hormone axis may be a precipitating factor in the development of PPS.^{67,68}

While none of these theories have been completely excluded, not enough evidence exists to strongly support any of them at present.⁶⁹

The Combined Effects of Disuse, Overuse, Pain, Weight Gain or Other Illnesses

Gawne and Halstead (1995)⁵ discussed the way a number of factors may interact with each other and contribute to the development of progressive weakness and fatigue. Figure 3 is a schematic model of the possible aetiological factors for PPS and their interactions.

Chronic overuse of muscles may result in the development of new weakness, which in turn may lead to disuse. Musculoskeletal disuse leads to further weakness, atrophy, contractures, diminished endurance and weight gain. In the presence of overuse, musculoskeletal pain may occur, causing the individual to either rest, resulting in deconditioning, or compensate with improper body mechanics, leading to further overuse and possibly pain elsewhere.⁵ This complex clinical picture presents a challenge to those attempting to diagnose and manage people with the LEOP.

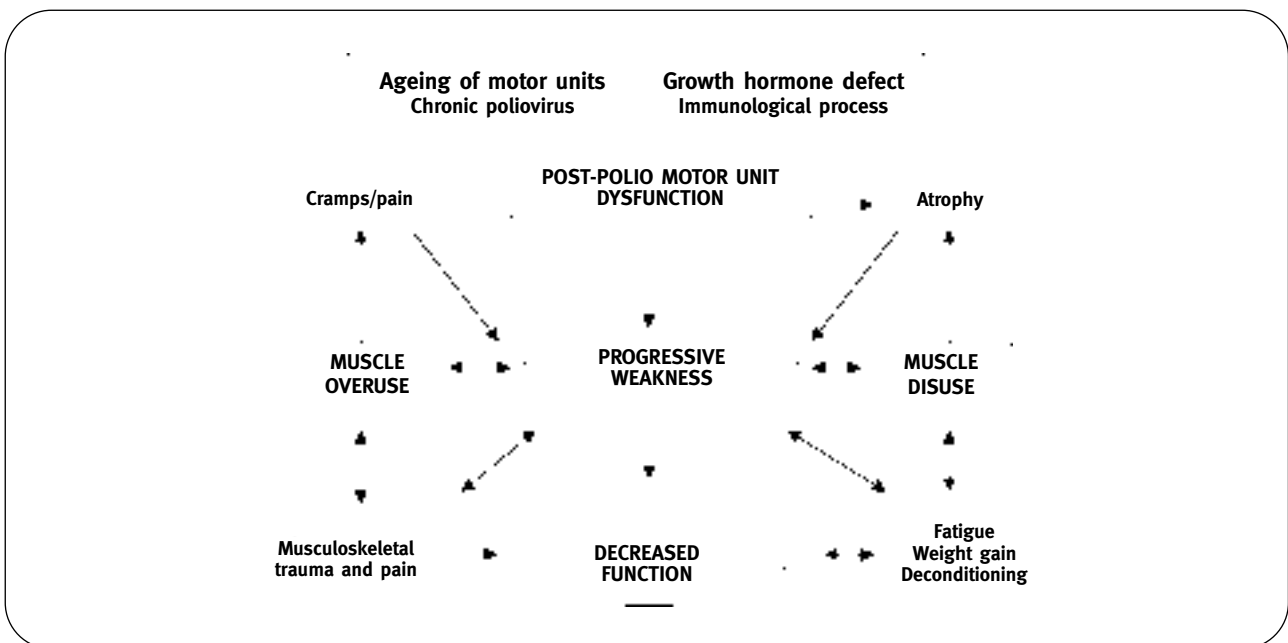


Figure 3: Schematic Model Demonstrating Possible Aetiological Factors for the Late Effects of Polio and their Interactions

(Adapted from Gawne and Halstead, 1995)⁵