

Polio: Its Impact on the People of the United States and the Emerging Profession of Physical Therapy

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Admittedly, it may appear incongruous that a review of a disease that infected the nervous system of persons in the first half of the twentieth century would appear in the *Journal of Orthopaedic & Sports Physical Therapy* at the start of the twenty-first century. As will be described, however, most of the physical therapy procedures developed during the polio epidemic involved muscles and their interaction with the skeletal system. Many of the treatments and rehabilitation philosophies created during this time are still very evident today. The “polio days” presented an enormous challenge and an equally enormous opportunity for the budding profession of physical therapy. Much of the growth had to do with timing. Managing the rehabilitation of hundreds of thousands of persons, many in the prime of their own lives or careers, required just the services that a physical therapist could potentially provide. In essence, the polio epidemic created a unique void in the medical arena—a void that was filled by the rapid expansion of the profession of physical therapy.

A full appreciation of the impact that the polio epidemic had on the profession requires a history lesson of the many interrelated and concurrent events that transpired in this country between 1916 and 1955. Within these turbulent times, the United States experienced 2 world wars, the Great Depression, the Korean War, and the insidious rise and swift fall of the polio epidemic—one of the most significant public health epidemics ever to strike the United States. For more than 2 decades leading up to the success of the Salk vaccine in 1955, the treatment and care of persons with polio dominated virtually every aspect of the physical therapy profession. The full story of how the growth, politics, philosophy, and

even “personality” of physical therapy were shaped by the interactions between physical therapists and those infected by polio has been well chronicled. Two notable works are a recent article by Dr Marilyn Moffat⁴² and a very well presented text, *Healing the Generations: A History of Physical Therapy and the American Physical Therapy Association*, by Ms Wendy Murphy.⁴⁴ This present historical review, intentionally less global than the aforementioned works, focuses more on the poliovirus itself, its impact on those it infected, and, most importantly, on several important lessons and benefits gained by the profession’s steadfast involvement with the epidemic.

Polio: The Virus and its Effect

The poliovirus, in its worse form, infects and incapacitates the anterior horn cells within the gray matter of the spinal cord, as well as motor nuclei in the brain stem. The term *polio* is short for *poliomyelitis*, a term derived from Greek, meaning “inflammation of the gray matter.” Polio was originally referred to as *infantile paralysis*, based on its propensity to infect children (Figure 1). This name, although appropriate in the early days of the epidemic, inaccurately reflected the true demographics of the disease, as untold thousands of adults were also stricken by the virus.

The poliovirus is a very small RNA virus about 27 nm in diameter.⁴¹ Classified as an enterovirus, polio gains access to its host primarily through the mouth or pharynx and subsequently infects the gastrointestinal tract. After multiplying within the body’s lymph nodes, the virus is absorbed into the bloodstream as well as eliminated in the stool, where it can be spread via the fecal-oral route to other persons in cases of poor hygiene. Interestingly, like smallpox, humans serve as the only natural hosts for the poliovirus. The overwhelming majority of polio infections were referred to as abortive, or

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FIGURE 1. A young girl with poliomyelitis involving both her upper extremities (circa 1950). Photograph courtesy of Ms Evie Hallas, PT.

nonparalytic, causing relatively mild symptoms of fever, malaise, headache, and nausea. Many people were, therefore, unaware of being infected, which likely contributed to the rapid spread of the virus. In about 1% to 2% of cases, the virus infected the motor cells of the spinal cord or brain stem, causing severe muscle pain and spasm, headache, backache, fever, and, most devastatingly, acute paralysis.⁵ Fortunately, the paralysis resolved significantly in most persons, generally within 6 to 8 months following onset.¹⁴ The extent of recovery for many, however, was literally the difference between life and death, dependence on and freedom from artificial respiration, or walking and permanent confinement to a bed or wheelchair. Further modest return in muscle strength was still possible up to 12 to 18 months after infection. Reliable data are hard to verify, but roughly 10% to 40% of persons recovered full muscle strength; the remaining 60% to 90% were left with varying degrees of residual paralysis, typically ranging from near total paralysis and subsequent death to only isolated paralysis of selected muscles.^{41,60}

The gradual increase in muscle strength over time likely was the result of reduced inflammation within the infected gray matter, and the fact that some of the unaffected axons formed terminal sprouts that reinnervated the previously “orphaned” muscle fibers. Furthermore, regardless of the size of motor units, innervated muscle fibers still retained the adaptive capacity to hypertrophy when challenged by resistive exercise. Many long-term survivors of paralytic polio have shown an exaggerated loss of strength 20 to 30 years after the original onset of the disease, possibly indicating a finite adaptive capacity of chronically overburdened motor units. This condi-

tion, known as “post-polio syndrome,” will be addressed at the conclusion of this review.

The extent and pattern of the permanent paralysis resulting from polio appeared haphazard and spotty, although the muscles in the lower extremities—most notably the quadriceps proximally and the anterior tibialis distally—were affected with greatest frequency.⁴⁸ As I recall one of my professors saying, “The poliovirus affected motor cells like a shotgun blast fired into a flock of birds; there was no pattern or predictability to the extent and permanence of the paralysis.” The unpredictability of the extent and permanence of the paralysis added another level of suspense for the patient and families, especially when so many children were infected. As one gentleman with severe polio once told me, “After the initial fever and full paralysis, all you could do was wait and see what the scourge had in mind for you.” Adding insult to injury for those children and families during the early days of the epidemic, were the obligatory placards posted on homes that read, “Infantile paralysis: stay off this street.”²³

The poliovirus that infected the motor cells in the cervical spine and brain stem resulted in the more severe “bulbar” type of paralysis. Paralysis of the muscles of swallowing and ventilation caused death in many or, in the case of paralysis of the diaphragm muscle, permanent dependence on the dreaded “iron lung.” This life-saving device (formally, but rarely, known as the “Drinker respirator,” after its inventor) consisted of a full-body-sized iron chamber that functioned as a mechanical bellows.²³ Patients lay supine within the chamber which was totally sealed below the neck. Mechanically lowering and raising the air pressure within the chamber forced air in and out of the patients’ lungs. This mechanical system was designed in 1928 and mass-produced as a response to polio. The iron lung later evolved to the more favorable and practical positive pressure ventilators used today. Many patients with severe respiratory difficulty were able to avoid the iron lung and breathe by lying in a “rocker bed.” As the head of the bed mechanically rose to the near vertical position, gravity pulled the abdominal viscera downward, thereby expanding the thoracic cavity and lowering intrathoracic pressure. Acting like a mechanical bellows, the reduced pressure in the thoracic cavity created a suction that drew air in through the mouth and nose. As the head of the bed was rhythmically lowered, the abdominal viscera returned upward to its normal position, thereby compressing the intrathoracic cavity and pushing air out of the lungs. Many people lived their entire lives using these systems of ventilation. Interestingly, due to the intensive nursing care required for persons using iron

lungs and rocker beds, several dozen patients were typically housed in 1 central location, a concept that later evolved into the intensive care unit (ICU). In these times, physiotherapists, as we were once called, also functioned as respiratory therapists, gaining some of our first practical experiences working within the ICU.²⁴ In addition to providing physical therapy, physical therapists also helped with many of the basic nursing and self-care needs of the patients, especially with helping to wean the patients from the artificial ventilation.³

The poliovirus produced the classic lower-motor-neuron symptoms of paralysis, atrophy, and fasciculation within muscle, and the loss of deep tendon reflexes. In addition, the weakened muscles became irritable and exhibited very painful spasms—a hallmark of poliomyelitis. The muscle spasms persisted from days to weeks, which, in addition to limiting pain-free movement, contributed to an imbalance of forces about the joints and subsequent contracture. (The muscle spasms should not be confused with muscle spasticity which typically occurs following pathology of or injury to upper motor neurons.) After the spasms resolved, the paralyzed muscles became flaccid and generally atonic, which is more typical of lower-motor-neuron disease. Of utmost clinical importance was the fact that persons with polio had an intact sensory system. This fact had a huge physiological and psychological impact on patients. Because persons with polio retained sensation, the incidence of pressure ulcers was very low, a fact that unfortunately cannot be stated for persons with involvement of both sensory and motor systems, such as spinal cord or peripheral nerve injury, diabetes, or Hansen's disease (leprosy). Even with significant muscle loss, the sparing of sensation in persons with polio typically permitted normal, or at least functional, control over bowel, bladder, and sexual functions.

The Polio Epidemic, FDR, and the Profession's "Windfall"

The first major outbreak of polio in the United States occurred during the transition between the nineteenth and twentieth centuries, with many cases occurring in the state of Vermont. An even larger epidemic occurred in 1916, which, at least historically, marked the beginning of the polio epidemic. The 1916 outbreak, first reported in New York City, infected more than 27 000 persons in 26 states, resulting in approximately 6000 deaths and thousands of cases of paralysis.²³ Although the cases of polio rose naturally during the warmth of the summer months, the summer of 1916 was particularly dismal

for New York City. In total, 8900 cases were reported, with a case fatality rate of 27%. Remarkably, the New York epidemic caused paralysis in 2% of all children under 2 years old.⁷⁰ Because so little was known about the virus or its inconspicuous mechanism of transmission, fear and near panic occurred as parents forbade their children from attending public places where large numbers of people gathered. According to data presented by Wyatt, the annual incidence of polio peaked in the US in 1916 at 41 cases per 100 000 persons (Figure 2).⁷⁰ The incidence dropped but remained relatively constant between 1917 and 1943. The number of cases rose again, however, and peaked at an alarming 35 per 100 000 people in 1952, just prior to the development of the polio vaccine. Throughout the entire epidemic (1916-1955), the poliovirus infected an average of about 38 000 people per year.

Ironically, the polio epidemic within the United States was fueled, in part, by the gradual improvement in sanitation and overall public health standards. Poorer sanitation prior to this time resulted in a constant exposure to the virus, which enhanced a natural immunity within the population. An interesting characteristic of polio was that it spared no particular gender, race, or socioeconomic background. Several well-to-do or prominent persons contracted polio of varying levels of severity,⁷ for example, Itzhak Perlman (violinist and composer), Tenley Albright (surgeon and first American woman to win an Olympic gold medal in figure skating), Wilfrid Sheed (author and critic), Mia Farrow (actress), Francis Ford Coppola (film director, producer, screenwriter), Tanaquil Leclercq (ballerina, teacher), Wilma Rudolph (winner of 3 gold Olympic medals in track and field), William O. Douglas (Supreme Court Justice), and Franklin Delano Roosevelt (32th president of the United States).

The fact that Franklin D. Roosevelt, or FDR as people so fondly referred to him, contracted paralytic

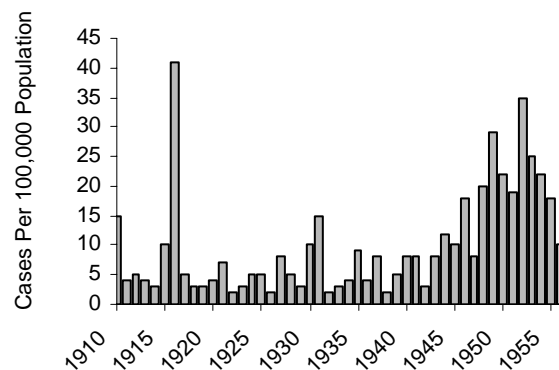


FIGURE 2. Graph showing the annual incidence of polio in the United States between 1910-1955. Data replotted from Wyatt.⁷⁰

polio in 1921 at the age of 39 years old had an enormous impact on the treatment, research, and public recognition of polio, as well as the growth, organization, and visibility of the profession of physical therapy.^{23,44} In 1926, still struggling with his own physical rehabilitation, FDR purchased a spa in Warm Springs, Georgia, known for the potential healing qualities of its water. The publicity and hope surrounding this purchase quickly led to the establishment of the Warm Springs Foundation, a facility that became a focal point for research and education on matters related to rehabilitation following poliomyelitis. This facility spawned many important pioneers in the treatment of polio, including Robert L. Bennett, MD, Medical Director,^{6,23} LeRoy W. Hubbard, MD, Surgeon-in-Chief,²⁷ and Ms Alice Lou Plastridge,^{23,44,51} Director of Physical Therapy (1929-1949), and, for a time, FDR's personal "physio." Under FDR's ever-present influence, Georgia Warm Springs developed extensive hydrotherapy programs combined with exercise (or hydrogymnastics as it was known). In addition, through funding and technical support from the Pope Foundation, this facility helped design and test the Hubbard tank and many of the original metal-and-leather leg braces, including the once-popular Klenzak dorsiflex-assist brace.²³

In 1937, FDR formed the National Foundation for Infantile Paralysis (NFIP). This Foundation served as the primary funding source for the treatment, education, and research related to polio. The Foundation later created the very popular March of Dimes campaign, which spearheaded much of the fund raising for the NFIP. FDR appointed his friend and law partner Mr Basil O'Connor as president of the NFIP; several years after FDR's death in 1945, Mr O'Connor led the campaign that ultimately funded the development, testing, and successful implementation of the polio vaccine. In the early 1950s, the NFIP spent 10 times more money on polio research than did the tax-supported National Institutes of Health.⁵⁸

During and following World War II, the relatively new profession of physical therapy was faced with the dual challenge of providing rehabilitation for the large number of injured war veterans and managing the resurgence in the number of cases of poliomyelitis. As a response, in 1945, through collaboration with the American Physiotherapy Association (renamed American Physical Therapy Association in 1946), the NFIP dedicated \$1 267 600 dollars for the advancement of physical therapy for the treatment of paralytic polio.⁴⁹ One primary focus of the funding was to reduce the severe shortage of qualified and university-educated physical therapists.⁴³ As stated by Mr Basil O'Connor in the *Physiotherapy Review* (later known as the *Physical Therapy Review* and eventually *Physical*

Therapy), "Today there are only 2500 qualified physical therapists, of whom more than half are in the Armed Forces . . . With earlier and more extensive use of treatment of infantile paralysis, twice the number already trained could be used for this disease alone."⁴⁹ The scope of the NFIP's financial commitment was huge, considering not only the times, but also the Foundation's prior financial commitment to the profession. The commitment of the NFIP proved to be a milestone for the profession, especially in terms of assisting the continued development of the American Physical Therapy Association (APTA), expansion of professional services, increased number of schools and instructors, and recognition by the public.

The *Physical Therapy Review* served as a primary vehicle for the dissemination of information and educational materials from the APTA and NFIP to the physical therapists in the field, to patients and their families indirectly, and to potential new physical therapy students. The *Review* regularly published articles on the treatment of polio, written by both physicians and physical therapists, including a series of monthly issues dedicated exclusively to polio and its treatment (note July issues of *Physical Therapy Review* of 1951, 1952, and 1953, and volume 27, 1947). In essence, these times marked the origins of a physical therapy literature authored by physical therapists, many of whom became prominent and recognized leaders in the field, such as Signe Brunnstrom,^{11,12} Henry and Florence Kendall,³⁴ Margaret Knott,³⁰ Catherine Worthingham,⁶⁸ Alice Lou Plastridge,⁵¹ Lucille Daniels,¹⁵ and Margaret Moore.⁴³ The writings of these and other authors have been well imbedded within the fabric of physical therapy practice and education. Frequently coauthored by mentoring physicians, physical therapists were starting to publish new topics and ideas: hydrotherapy,^{38,40} electrical stimulation,⁵⁶ tilt tables,¹⁹ prevention of deformities,^{34,51} gait deviations and training,^{52,55} functional outcomes and tests,^{6,59,63} respiratory care,^{3,21,24} specialized exercise equipment for the home,⁶¹ and reliability of muscle strength testing.³⁶

In addition to the more technical literature, *Physical Therapy Review* published updates on the status of the development of the polio vaccine, the number of people infected within a current year, recruitment ads for students, and public health prevention messages, such as the "Polio Pledge" published in 1952 (Figure 3). The "Polio Pledge" was also sent by the NFIP to 35 million homes across the United States. The tone of some of the pledges, especially some of the "I will not" items, provides interesting insight into the austerity of the times and obvious concern that must have been felt by parents.

POLIO PLEDGE

If Polio Comes to my Community

I will remember to...

- Let my children continue to play and be with their usual companions. They have already been exposed to whatever polio virus may be in that group, and they may have developed immunity (protection) against it.
- Teach my children to scrub their hands before putting food in their mouths. Polio virus may be carried into the body through the mouth.
- See that my children never use anybody's towels, wash cloths or dirty drinking glasses, dishes and tableware. Polio virus could be carried from these things to other people.
- Follow my doctor's advice about nose and throat operations, inoculations, or teeth extractions during the polio season.
- Be ever watchful for signs of polio: headache, fever, sore throat, upset stomach, tenderness and stiffness of the neck and back.
- Call my doctor at once and, in the meantime, put to bed and away from others any member of my family showing such symptoms.

I will not...

- Allow my children to mingle with strangers, especially in crowds, or go to homes outside their own circle. There are three different viruses that cause polio. My children's group may be immune to one of these. Strangers may carry another polio virus to which they are not immune.
- Let my children become fatigued or chilled. Over tired or chilled bodies are less able to fight off polio.
- Take my children away from our community without good cause. Polio time is the time to stay at home and keep everyday companions.

If Polio Comes to My Home

I will...

- Have confidence in my doctor, knowing the earlier the care the better my child's chances for complete recovery. I know that my child has a better than even chance to recover without paralysis.
- Call my local chapter of the National Foundation for Infantile Paralysis immediately for information or help. The telephone book or my health department will tell me how to reach the chapter.
- Remember that whatever financial help my family needs for folio care will be given through the chapter. This is made possible by the gifts of the American people to the March of Dimes each January.

FIGURE 3. The Polio Pledge. Retyped from *Phys Ther Rev.* 1952;32:246,272.

Despite the intense effort of the NFIP to reduce the spread of polio, the numbers of infected persons continued to rise throughout the late 1940s and into the early 1950s. The number of cases peaked in 1952 at more than 57 000, second only to the 1916 epidemic. Although an extreme example, the number of new cases of polio in Nebraska in 1952 reached 98 per 100 000 persons, or nearly 1 in every 1000 persons.⁹ The shortage of qualified physical therapists became even more acute.⁶⁸ Dr Catherine Worthingham, who served in leadership roles in both the APTA and NFIP, widely promoted educational scholarships for students of physical therapy. In late 1952, the *Physical Therapy Review* reported that one third of all practicing physical therapists in the country had received prior educational scholarships from the NFIP.⁵⁰ By 1955, 80% of all physical therapy students were enrolled in degree programs.⁴⁴

In continued response to the critical shortage of physical therapists relative to the rising number of cases of polio, the NFIP funded the Polio Recruitment Service within the APTA.^{28,53} The purpose of this service was to recruit and relocate so-called “shock teams” of physical therapists to 3- to 6-month assignments in underserved epidemic communities (see a sample advertisement in Figure 4). Many of the needy were severely paralyzed children dependent on the iron lung for ventilation. Between 1948 and 1960, more than 1000 physical therapists volunteered for these assignments.⁴⁴

Essentially all of the funding in the later years of the polio epidemic was linked to the earlier vision and efforts of Franklin Delano Roosevelt. FDR not only served as an impetus for the growth of the profession of physical therapy, but also a source of inspiration and hope for many persons with polio. After all, consider the odds of a man in the 1930s and 1940s with paraplegia from polio—decades before the Americans With Disabilities Act—being twice elected governor of New York, and later to 4 consecutive terms as president of the United States. On April 12, 1945, while in his fourth term, FDR died of a

ATTENTION!

There is a critical need for physical therapists to serve in polio epidemic areas. The 1952 polio incidence is high and requests for temporary assignments have been received much earlier than in previous years.

If you know of a physical therapist who can be made available please communicate at once with:

**Polio Recruitment Service, 1790 Broadway, New York 19, N. Y.
or call Judson 6-2932 collect.**

FIGURE 4. A typical recruitment notice appearing in *Physical Therapy Review* in the early 1950s. Copied from *Phys Ther Rev.* 1952;32:449.

cerebral hemorrhage at the age of 63 while in Warm Springs, Georgia. The polio epidemic would rage for another 10 years; his leadership, however, provided the continued impetus that eventually led to the near eradication of the disease.

The Evolution of Physical Therapy Practice During the Polio Epidemic

Medical treatment for persons with poliomyelitis was aimed primarily at the effects of the virus, rather than the virus itself. As reported in *Physical Therapy Review* in 1954, physical therapy focused on these 6 major conditions: loss of flexibility, loss of muscle power, decreased vital capacity, the potential for deformity, loss of skill, and loss of functional stamina.³⁹ Although differing views were held, 3 stages of treatment were generally recognized: acute, convalescent, and chronic.⁵¹ The acute (febrile) stage, lasting 2 to 3 weeks, usually included a limited period of isolation. The main objectives of this phase were strict bed rest, light stretching of muscles to prevent contracture, proper positioning and support of weakened muscles and joints, hot packs to reduce painful muscle spasms, and, if needed, life support procedures in the cases of severe respiratory involvement. It was generally believed that while patients remained febrile, increased physical activity increased the severity and likelihood of permanent paralysis.

The longer convalescent stage of treatment lasted up to 18 months, depending on the initial severity of the disease. This stage of treatment corresponded to a slow but continuous return in muscle strength. Many of the preventive measures used in the acute stage were applied as needed in the convalescent stage. Massage, whirlpool, salt baths, heat, and electrical stimulation were also continued in an effort to limit painful muscle spasms. After the eventual cessation of spasms, the muscles demonstrated varying degrees of flaccid paralysis. Patients often learned to substitute for the loss of a paralyzed muscle by incorporating similar functions of surrounding, stronger muscles. This ability to substitute muscle function was significantly enhanced in patients with polio because of their ability to perceive proprioception and overall sensation within and around their joints. Although this compensatory ability typically permitted the performance of basic active movements, the initial attempts of these movements often lacked control, strength, and stamina. This set of symptoms, characteristic of many persons with polio, led to the creation of the once very popular “muscle re-education” exercises.^{25,51} In conjunction with the use of hot packs, hydrotherapy, and muscle stretching, muscle re-education exercises were the mainstay of

much of the physical therapy administered throughout the epidemic. Patients were instructed to deliberately and repeatedly perform specific actions of muscles, while the therapist typically assisted or facilitated the movement through verbal and tactile cuing. Resistance was applied sparingly to individual muscles and only if it could be matched by the patient. This method of treatment required the therapist to understand not only the potential actions of individual muscles, but also the specific strength grades (based on the traditional 0-to-5 manual muscle testing system) of their individual patients, which changed—in some cases daily. Re-educating muscles by combining sensory input with very specific active movements is still evident in parts of today’s physical therapy practice.

As the months passed, the tenderness and spasm in muscles typically abated, and, for many, muscular strength and control increased. As the muscles grew stronger, therapists applied greater resistance, based, at least in the later days of the epidemic, on the new theory of “progressive resistance exercise” (PRE) advocated by DeLorme.¹⁸ Resistive exercises were ideally performed in conjunction with water submersion, either in therapeutic pools or Hubbard tanks—a definite FDR and Warm Springs influence! As the patient’s strength and stamina continued to grow, the emphasis of treatment shifted to converting muscle strength to functional performance. A first priority was self-care and basic mobility, such as transferring to and from commodes and baths, and using a wheelchair. Gait training was typically pursued vigorously when possible, often with the assistance of relatively heavy leg braces,⁶⁶ at least compared to those used today.

Consider the richness of the challenge, both intellectually and physically, for the relatively few physical therapists of the time. At the peak time of the epidemic, literally tens of thousands of patients with polio at any given time across the country were pursuing gait training. It was during these times that the first papers began to appear in the physical therapy literature on gait training, classic gait deviations, the use of Canadian crutches,⁵² and applying the fundamental crutch-walking patterns, such as the 2-, 3- and 4-point, tripod, and swing gait.⁵⁵ The expertise developed in this area at that time was likely largely responsible for gait training being so firmly entrenched in our present-day scope of practice.

The chronic stage of treatment of polio followed the cessation of spontaneous recovery of muscle function. The focus of treatment was to maximize functional potential, with the assumption that the existing level of paralysis was permanent. This stage of treatment was often very creative for both the

therapist and patient. Long-term plans for maximizing mobility were addressed, often involving leg bracing, splinting, specialized exercise equipment, and adaptations to the home and vehicle. This stage of treatment also involved the development of innovative “tendon transfer” surgeries, designed to increase power and to balance the muscular forces across joints. Physical therapists were largely responsible for the postsurgical rehabilitation, emphasizing once again the need for therapists to thoroughly understand the individual actions of muscles.

The rehabilitation of persons with polio must have provided a very rewarding personal experience for the physical therapists. By having normal sensation, many patients with polio had the almost uncanny ability to mask much of their muscle weakness, typically through activating adjacent stronger muscles that had similar actions, using innovative bracing, and taking advantage of gravity to mechanically stabilize their joints. As stated by Ms Martha Wroe, a longtime academician and physical therapist who worked with patients with polio, “Patients with polio could be taught to perform movements that, based on the severity of their paralysis, seemed almost impossible.”⁶⁹ Many patients, therefore, had an enormous functional potential, partially because of their spared sensation, but also because of the continued gains in strength, at least for the majority. Another important consideration was motivation. Recent return in strength and associated function generated a valuable source of optimism. The apparent cause-and-effect relationship between the amount of effort placed on one’s rehabilitation and the resulting functional accomplishments were very apparent to many polio survivors, as well as to their physical therapists. According to Lauro Halstead, a polio survivor, physician, and director of the spinal cord injury and post-polio programs at the National Rehabilitation Hospital in Washington, DC, “When a physical therapist prescribed 10 repetitions twice a day . . . , patients typically would do 20 or more repetitions 3 times a day . . . [the patients with polio] experienced a new mastery over their muscles and movements, an element of control that had not existed before [their] polio.”²⁶ Dr Halstead also explained that the strong work ethic established during their rehabilitation carried over into many other aspects of their lives. According to Halstead, polio survivors were generally more educated than the general population, and had a rate of employment about 4 times greater than other persons with disability.

It is difficult to know with certainty the extent to which the prevailing positive attitude of so many of the polio survivors actually had on their successful rehabilitation. My personal experience and research

in this historical perspective suggest that it was very significant. Furthermore, I submit that the young, impressionable profession of physical therapy recognized the power of this positive attitude and subsequently adopted it, consciously or not, as a core feature of the profession’s rehabilitation philosophy. Certainly, there have been such positive influences made by other patient populations over the years, but the attitudes of many of the persons with polio have made an indelible mark on the “heart” of the profession—a characteristic that has been passed down across subsequent generations of physical therapists.

The Orthodox View of Physical Therapy Receives a Major Challenge

Although regional differences existed in the United States, the orthodox approach to physical therapy during the earlier stages of treatment of polio consisted primarily of muscle re-education, hydrotherapy with moderate exercise and stretching, and hot packs to limit muscle spasms. Underlying this approach, many leading physicians and physical therapists (including the pair of therapists based in Baltimore, Maryland, Henry and Florence Kendall) felt that severely weak muscles below the 50% (3/5) muscle test grade should be protected from fatigue, contracture (overshortening), or from being overstretched. As a consequence, clinicians generally advocated avoidance of exertion and the use of splints to maintain neutral positions of weakened joints. This prevailing orthodoxy was considered too conservative by some, but nevertheless was generally accepted as standard practice.⁶

In 1938, the Kendalls were invited to submit the US Public Health Bulletin No. 242: Care During the Recovery Period in Paralytic Poliomyelitis.³² This invitation demonstrates the respect the US government held for the Kendalls. One theme of the Bulletin was their description of the phenomenon of muscle “stretch weakness,” described more formally in a later publication.³⁴ The Kendalls, as well as other orthopedists, had observed that chronically overstretched muscles, whether affected by polio or not, gradually weakened. Stretch weakness, according to the Kendalls, was especially relevant to muscles that had already been weakened by polio. Consider, for example, the ankle dorsiflexor muscles, which were so commonly affected by polio. This muscle group was often chronically overstretched because of the overpowering pull of the plantar flexor muscles, and, especially in this example, the pull of gravity. The plantar flexors typically overpowered the dorsiflexors because either they were not as affected by the virus

or, even if equally affected, the spasms in the larger plantar flexor musculature dominated the ankle posture. It was reasoned, therefore, that splinting or otherwise maintaining joints in a neutral position would protect the very weak muscles from being overstretched, and thereby prevent a further diminution in strength. Interestingly, the physiologic basis of stretch weakness was never studied extensively until well after the polio epidemic. Using an animal model, it has been shown that the numbers of sarcomeres within chronically elongated muscles increased in series, which, over time, significantly altered the muscle's length-tension relationship.^{62,67} A dramatic shift in this relationship can account for a clinician's perception of "stretch weakness," especially when tested at the muscle's relatively shortened length.^{22,46,47}

In hindsight, it is possible that physical therapy for the severely weakened muscles from polio was, at times, too conservative and may have contributed to disuse-related problems in other muscles or systems of the body. The acceptance of this conservative approach, however, was driven by the prevailing belief that most persons with paralytic polio would eventually regain a good portion of their muscle strength. It seemed like good practice to many, therefore, to use whatever appliances or treatments necessary to prevent irreversible injury, deformity, or further weakness of muscles that would otherwise limit the patient's long-term functional potential. The Kendalls emphasized that immobilization of joints should be used judiciously and only with the goals of preventing subsequent joint instability and deformity. The Kendalls were clear to make this and other points in their rather frank rebuttal, *Let's Immobilize False Impressions*,³³ that "Treatment is tailor-made for each individual and employs physical therapy measures necessary to obtain the best possible results for each individual." The Kendalls also emphasized that treatment "accompanies the rest and protection—it does not follow after periods of immobilization."

Although the orthodox approach to physical therapy prevailed for many years of the epidemic, it was not without its outspoken critics. In 1953, just 2 years prior to the successful vaccine against the poliovirus, Kabat and Knott³⁰ published an article stating that the standard use of muscle re-education exercises built upon the premise of "rest and muscle protection" was not the most appropriate treatment for persons with paralytic polio. They stated that this "outdated" approach led to "disuse of the neuromuscular mechanism" and had "detrimental effects on circulation and joint mobility." The new approach developed by the Kabat-Kaiser Institute in California, in contrast, was based on resistive exercise,

even in the acute period, without significant concern for avoiding muscle stretch or fatigue. Resistance was applied to mass movement patterns of limbs (instead of isolated movements) and combined with facilitation techniques using quick stretch and reflexes. This relatively new treatment approach was called proprioceptive neuromuscular facilitation (PNF). To my knowledge, Kabat and Knott's 1953 paper was one of the first publications in the physical therapy literature that advocated the use of PNF for treatment of lower-motor-neuron disease.

There is no question that the greatest critic of orthodox practice of physical therapy during the polio epidemic was not from within the United States, but from an outspoken, charismatic, and self-proclaimed Australian "nurse" named Sister Elizabeth Kenny.²³ Sister Kenny (the title *Sister* reflecting her previous role as an Australian army nurse) developed her own approach to treating patients with polio, starting as early as 1911 while working in the back country of Australia. Her arrival in the United States in 1940 stimulated a decade of controversy within the medical and physical therapy community. Sister Kenny believed that polio was a disease that originated in muscle, not in the nervous system. This view was totally contrary to contemporary medical dogma. Furthermore, she taught that most patients were not paralyzed in the strict sense, rather they "forgot" how to activate muscles due to prolonged immobility caused by the very painful spasms. Sister Kenny described this paralysis as "mental alienation" between the patients and their painful muscles. The "Kenny method," therefore, was based primarily on reducing muscle spasms and early mobilization of limbs; to this end, she stressed massage, extensive stretching of muscles, and nearly continuous and labor-intensive application of moist heat wraps made of heavy woolen cloth. In addition, to break the mental alienation, she taught her patients to make a conscious link between muscle activation and their associated movements. The Kenny approach was in direct opposition to much of the standard contemporary approach of physical therapy not only in the United States but also in England and Australia.

Sister Kenny continued to vocalize the benefits and successes of her treatments, and how the traditional practice of immobilizing muscle contributed to paralysis by increasing the alienation of muscles. She objected to the use of braces, splints, and even, for some patients, the iron lung.²³ Kenny claimed that her approach to treatment had an 80% success rate compared to 13% for the orthodox treatments.³⁵ Although unorthodox, unsubstantiated, and misunderstood, the Kenny approach gradually established a loyal following, primarily because her approach was

refreshingly different in so many ways. At that time, more than 20 years into the epidemic, the public and segments of the medical community in the US were frustrated with the lack of success of the orthodox approach. Fueling her popularity was her domineering and assuring presence, coupled with a seemingly inexhaustible supply of energy and genuine unselfish dedication to her patients. Patients under her care were, by far, her main supporters. One patient under her care stated, "She was a tall and elegant woman, and she inspired confidence just by her manner and by the way she carried herself; . . . [her] intensity demanded all of your attention, and when she spoke, people listened to her."⁵⁴

In 1943, the American Medical Association (AMA) convinced the National Foundation for Infantile Paralysis to fund a practice for Sister Kenny in the US, including a staff of 20 physical therapists, at the University of Minnesota Medical School and Minnesota General Hospital.⁴⁴ This practice and additional private funding led to the Sister Kenny Institute, which expanded to include training satellites for physical therapists and physicians around the country. At the height of her popularity, Sister Kenny was invited to demonstrate her techniques to 3500 doctors and nurses at the 1942 annual meeting of the AMA. She also received honorary doctoral degrees from prestigious universities and dined with Franklin D. Roosevelt.²³

The Kenny approach to treating patients with polio created dissent among health care leaders in the United States.³¹ This is particularly evident by the tone of Sister Kenny's invited commentary published in the *Physiotherapy Review* in 1943.³⁵ Relatively non-productive and contentious meetings were held between Sister Kenny and several therapists and physicians, including the Kendalls from Baltimore Children's Hospital School, Mildred Elson and Gertrude Beard from Northwestern University (Chicago), and Alice Lou Plastridge from Georgia Warm Springs.^{23,44} The differences between Sister Kenny and the others were essentially irreconcilable. Apparently, more objective third-party analysis of the treated patients later showed that the results of the Kenny approach were generally similar to those obtained through traditional, orthodox approaches to treatment.^{31,65} The NFIP eventually withdrew financial support for Sister Kenny in 1945, and her popularity slowly began to wane. The Sister Kenny Institute continued to thrive, however, from private funding sources. In 1952, Sister Kenny died at her home in Australia of a cerebral hemorrhage. An obituary, published in the *Physical Therapy Review*⁵⁷ stated, "The controversy and furor which she aroused

will be forgotten—and her deep abiding interest and service to the polio patient will be remembered."

The profession of physical therapy grew from the challenges imposed by Sister Kenny and others. Her strong opinion on the benefits of early mobilization, close interaction with patients, and the absolute necessity for relieving muscular pain as a prerequisite to movement certainly made a lasting impression on the profession's earlier therapists. As stated by Ms Alice Lou Plastridge, longtime Director of Physical Therapy at Georgia Warm Springs, ". . . her controversial theories have given a tremendous stimulation to further research in the field, and made many of us take serious stock of ourselves, and the type of physical therapy we are doing . . . That is itself a forward step."⁴⁴

The philosophical and technical approaches to treating paralyzed or weakened muscles continually evolved throughout the nearly 40-year epidemic. Although treatments administered at most facilities were considered relatively mainstream, pockets of more extreme approaches existed. Treatments ranged from relatively aggressive, early interventions consisting of near continued mobilization of the limbs, extensive use of heat wraps, or resisted-mass movement patterns, to a more conservative approach consisting of long-term rigid immobilization of joints and complete avoidance of muscle fatigue. There were likely situations when any or all of the above treatments were justifiable. The early profession learned from the experience of pushing the limits of treatment in either direction—remnants of which can certainly be found in today's practice of physical therapy.

A Closer Look at the Origins of Manual Muscle Testing

Any given whole muscle receives its innervation from many motor neurons, typically spread across multiple nerve root levels. Because the poliovirus infected anterior horn cells across the entire nervous system essentially at random, the pattern of paralysis for any given person was typically unique and often complicated. The "manual muscle test" was developed during the epidemic to document this pattern of paralysis for each patient. The results of this test provided the most direct insight into the severity and location of the patient's damaged motor neurons. In addition, knowledge of a patient's often-changing innervation pattern helped prioritize the immediate goals and strategies for managing the patient's most essential functions, from breathing to walking. The responsibility of manual muscle testing fell primarily on the physical therapists of the time, a logical

selection based on their close daily contact with the patients and their fundamental knowledge of anatomy, physiology, and exercise. Physicians could not, on their own, test and retest the overwhelmingly large numbers of patients. The polio epidemic, therefore, offered a very distinctive opportunity for physical therapists to become experts in a very valued area.

Dr Robert W. Lovett, Professor of Orthopedic Surgery at Harvard Medical School, first published the techniques for manual muscle testing in 1917,³⁷ 1 year following the large New York City polio epidemic. This technique evolved with the help of his experienced associate Wilhelmine Wright, who also authored the seminal text *Muscle Function* in 1928. At its inception, manual muscle testing was based on a systematic method of using palpation, gravity, external manual resistance, and arc of active movement to assign a relative strength grade to individual muscles. Lovett's original strength grades were referred to as trace, poor, fair, good, and normal.^{11,16}

At the onset of the epidemic, Dr Lovett was considered the leading authority in the treatment of polio. His early work concentrated on the large outbreaks of polio in the state of Vermont. Lovett's philosophy on the benefits of combining exercise with hydrotherapy was particularly appealing to many of his contemporaries, including Franklin D. Roosevelt and his personal physicians. Lovett also believed that it was important to closely and accurately monitor the strength of individual muscles weakened by polio and, armed with this knowledge, to teach patients to use stronger muscles to compensate for their weakness. This philosophy, rooted strongly in the very early days of the polio epidemic, remained well established in physical therapy practice throughout the 1950s and, arguably, to the present day.

Between 1917 and the early 1950s, several notable clinicians made slight modifications to the original muscle testing procedures developed by Lovett and Wright by adding indicators that described fatigue, body position, amount of spasm, and incoordination. These clinicians include the Kendalls, Signe Brunnstrom and Marjorie Dennen, Sister Kenny, Lucille Daniels and Catherine Worthingham, and Alice Lou Plastridge, who trained under Dr Lovett and Ms Wright.^{16,44} Over the years, however, the overall muscle testing process has remained remarkably similar to that first outlined by Dr Lovett.

In the early 1950s, manual muscle testing produced important data during the tests for the efficacy of gamma globulins and later the Salk vaccine as a prophylaxis to the poliovirus.⁶⁴ The largest study conducted in 1954 involved 1.8 million first- through

third-grade children in 200 counties throughout the United States.⁴⁴ The counties were selected based on their high previous polio incidence, especially involving young children. A large part of the study was designed as "double blinded" to prevent bias, with roughly 50% of the children receiving the vaccine and 50% receiving a placebo. Under the direction of Ms Lucy Blair, 67 physical therapists were chosen from across the country to participate in the muscle-testing phase of the research project. Through the guidance of Dr Jessie Wright and her colleagues at the D.T. Watson School of Physiatrics, in Leetsdale, Pennsylvania, the original Lovett muscle test grades were modified to produce a more quantitative measurement for statistical analysis. In 1955, it was announced that the Salk vaccine was 80% to 90% successful in preventing polio; the long epidemic was finally coming to an end.

Even now in the 21st century, manual muscle testing has a place within most, if not all, physical therapy curricula within the United States. This is interesting, considering that the test lacks the necessary objectivity required of a rigorous scientific measurement tool. Furthermore, the test was designed for a disease with a unique set of symptoms that no longer exists in this country. Its continued use likely reflects its practicality and simplicity, at least for cases where the muscles are not dominated by spasticity or other such upper-motor-neuron symptoms. It is likely, however, that its popularity has also been perpetuated, in part, simply out of respect for its once very important place within the core of the profession and its role in testing the efficacy of the Salk vaccine.

Polio and its Lessons on Kinesiology

The polio clinic was a virtual spawning ground for lessons in kinesiology. The often spotty and random pattern of muscle paralysis offered a unique window into the functional potential of muscles. It was not uncommon, for instance, for patients to present with a pattern of nearly all muscles within a group or region nearly paralyzed except for 1. The 1 innervated muscle was therefore allowed to express its unique action. These situations presented some of the original kinesiological evidence on the isolated actions of more complex muscles, especially those of the shoulder, hip, and hand.^{10,71} Understanding the full potential action of a single muscle provided more than just academic information. Physical therapists used this information to instruct patients on how to "share" a secondary or tertiary action of a stronger muscle for the primary action of a paralyzed one. Mr Samuel (Shep) Barish, a physical therapist who worked extensively with patients with polio, once described a classic example of this ability.⁴ A patient

with total paralysis of his deltoid and supraspinatus muscles retained the ability to abduct the glenohumeral joint, provided the shoulder was first fully externally rotated. Apparently, as it was explained, the patient used his innervated long-head of his biceps muscle to substitute for the loss of the more traditional abductor muscles.

It was also not uncommon for a patient with polio to present with complete or nearly complete paralysis of just 1 muscle within a muscle group or region of the body. The functional consequence of the loss of a single muscle on a region was often far greater than that predicted based on the paralyzed muscle's assumed isolated action. Isolated paralysis of the triceps, for example, significantly reduces the ability to effectively supinate the forearm.⁴⁵ The unrestrained biceps muscle uncontrollably flexes the elbow at every maximal supination effort. Isolated paralysis of the rhomboid muscle, although not attaching to the humerus, diminishes the strength of shoulder adduction and extension.¹⁰ In both examples, the paralyzed muscles failed to stabilize or neutralize another muscle's action—2 of the many important concepts popularized during the polio epidemic.

Signe Brunnstrom, in my opinion the founder of clinical kinesiology, shares many of her kinesiology lessons learned during the polio epidemic in a classic paper published in *Physiotherapy Review* in 1942.¹³ This paper, *Some Observations of Muscle Function: With Special Reference to Pluriarticular Muscles*, defines many of the fundamental principles of kinesiology of the musculoskeletal system. This paper marks the origins of clinical pathokinesiology within the physical therapy literature, and, from a historical perspective, is an essential read to those interested in this subject matter.

With a single muscle within a group paralyzed, it was often possible to infer that muscle's primary function by observing the pathokinesiological effect of its absence. Isolated paralysis of the tibialis posterior, for example, typically resulted in an eversion bias of the foot, reflecting the muscle's dominant role as an inverter. Signe Brunnstrom used this inverse logic throughout her writing on this subject. In 1941, she published a paper in the *Journal of Bone and Joint Surgery* based on her observations of the shoulder in patients with polio.¹² In one of her many examples, she describes the important retraction role of the trapezius muscle based on the subject's excessively protracted posture of the shoulder girdle. To my knowledge, this was the first kinesiological publication by a physical therapist in this prestigious journal. Although her kinesiological logic was relatively simple, it revolutionized the clinical analysis of muscle action, especially in regard to the manner that muscles

cooperate as a group. Two decades later in 1962, Signe Brunnstrom authored her classic textbook *Clinical Kinesiology*,¹⁰ a work that has influenced several generations of physical therapists. This work popularized concepts such as synergists, force couples, and proximal stabilizers—terms that remain in the lexicon of current kinesiology. Her pioneering text represented a synthesis of her years of observing kinesiology first hand in the clinic, working not only with persons with polio, but also in the area of prosthetics and rehabilitation following a stroke.

2004: For Some, the Struggle Continues

Throughout the late 1970s and the 1980s—20 to 30 years following the end of the polio epidemic—an alarmingly large number of aging polio survivors began to report a cluster of health-related symptoms, most commonly, debilitating fatigue, joint and muscle pain, and, most alarmingly, a new occurrence of muscle weakness. In 1994, following several medical conferences hosted by the Warm Springs Institute for Rehabilitation, this set of symptoms was recognized as an official medical entity known as “postpolio syndrome” (PPS).²⁶ It is noteworthy that, in general, the polio survivors did not report symptoms of PPS until 30 or 40 years after the initial onset of their disease.

At present, there is no definitive diagnostic test for PPS. The diagnosis is based primarily on symptoms, which Jubelt and Drucker have organized into 3 categories: systemic, neurologic, and musculoskeletal.²⁹ This organization was based on data obtained from 3 postpolio clinics. Overall mental and physical fatigue, or hitting the “polio wall,” is the most prominent systemic symptom, and reported in 75% of patients. The pathophysiology of the fatigue is not well understood. Less frequent systemic symptoms included intolerance to cold, sleep disturbance, and dizziness. The most common neurologic symptom of PPS is a new and, at times, progressive loss in muscle strength often associated with recent atrophy. This symptom has also been referred to as “postpolio progressive muscle atrophy.”⁸ This loss in strength is typically relatively sudden and usually not related to advanced age. Sudden loss in muscle strength is especially significant if it compromises functions such as breathing, swallowing, walking, or transferring independently. Previously weakened muscles are more likely to be affected in PPS than previously unaffected muscles. Also, the severity of the new weakness appears to be positively related to the severity of the original paralysis, the patient's age at the time of onset, and the amount of recovery.²⁹

Muscle and joint pain lead the list of musculoskeletal symptoms associated with PPS. The pain likely occurs in and around joints that have become

unstable or deformed from the many—and often very active—years of inadequate muscular support. Apparently, cumulative stress on the weakened muscles and joints gradually reaches a threshold point, thereafter resulting in varying mechanical disruptions, inflammation, and subsequent pain. For many persons, this threshold point occurs 3 to 4 decades after the onset of the disease. Some persons, however, reach this point much earlier, while others never do. Because this set of musculoskeletal symptoms is so closely associated with “wear and tear” arthritis, which occurs independently of polio, some clinicians refer to these symptoms as “late effects of polio,” reserving the term *post-polio syndrome* for the systemic and neurologic symptoms.

Of all the symptoms related to PPS, the new loss of muscle strength has received the most attention. Several theories have been advanced to explain this phenomenon.^{2,26,29} The most probable theory relates to a premature exhaustion of the axonal sprouts that formed in the months following the onset of the disease.²⁹ Normally, a single healthy motor unit may innervate 500 to 1000 muscle fibers. Following axonal sprouting, this same motor unit may compensate by innervating 5000 to 10 000 muscle fibers. These “giant” motor neurons may simply fail over time due to their increased metabolic demand. In short, the mechanism that provided much of the needed compensation 3 decades earlier has begun to fail. It is less likely that the muscle weakness is related to persistent poliovirus infection or an immune response to the damaged anterior horn cells.²⁶ Much remains to be learned about the etiology of PPS.

In 1987, the National Center for Health Statistics estimated that there were 640 000 polio survivors living in the United States and about half had reported new symptoms consistent with PPS.²⁶ It is likely, therefore, that a sizable population of polio survivors over the next 20 years or so will be seeking medical advice on this issue. An excellent web page lists the latest advances in medication and medical treatments for PPS (www.post-polio.org).

Physical therapy for PPS places a strong emphasis on patient education. Patients should be encouraged to stay as active as possible while avoiding pain and fatigue. Energy conservation measures and tips on pacing and frequent rests and naps are important. It is also important to reduce mechanical stress on joints, either through a weight loss program, light weight bracing, or a re-evaluation of the current use of walking devices or other mobility devices such as a wheelchair or a scooter. Modifications may be indicated in lifestyle as well as physical alterations in the work and home environments. Traditional physical

therapy may certainly be indicated to maintain flexibility and relieve joint and muscle pain.

Research suggests that the judicious use of exercise can increase cardiopulmonary fitness, muscle strength, and efficiency in ambulation in persons with PPS.^{1,8} Exercise programs must, however, be specially designed for each patient. Pain in muscles or joints must be avoided. Selected weak joints of the body should be especially protected. Exercises should be nonfatiguing and focus on submaximal resistance with short-duration repetitions. Any exercise program should begin with caution and progress slowly. All the precautions used for any aged population of patients should also be followed.

Poliovirus: Global Eradication by 2005?

The introduction of the Salk vaccine in 1955 led to a dramatic reduction in the number of people infected with poliovirus in the United States.^{17,54} In 1953, for example, there were 35 000 cases of new polio reported in the United States; in 1957, the first year the Salk vaccine was readily accessible to the public, the number fell to 5600. In 1961, Dr Albert Sabin introduced the more effective live vaccine that led to the complete eradication of the wild form of poliovirus from the United States. Not only more effective, the Sabin vaccine was also less expensive and could be administered orally. Being a live virus vaccine, however, the Sabin vaccine possessed the inherent risk—although very small—of actually causing paralysis in its recipient or being transmitted to others.²⁰ All cases of indigenous polio reported in the United States since 1980 have, indeed, been caused by the vaccine. For this reason, as of 2003, the Centers for Disease Control and Prevention (CDC) recommends the inactivated (and unfortunately injected) form of the polio vaccine for children in the US (refer to www.cdc.gov).

In 2004, poliomyelitis is finally on the verge of worldwide eradication. This has been accomplished by massive immunization campaigns organized and funded by several groups, including the World Health Organization (WHO), CDC, United Nations International Children’s Emergency Fund (UNICEF), Rotary International, Bill and Melinda Gates Foundation, the World Bank, and a host of individual countries and corporate partners.^{20,41} Since 1988, the number of countries in the world where poliovirus was endemic fell from 125 to 5.²⁰ The last case of wild polio in the western hemisphere was reported in 1991. The WHO expects to achieve total global eradication of the wild poliovirus by 2005, which would be one of the most remarkable feats in medical history.

Closing Thoughts

In writing this historical perspective, my intention was not to elevate the status of the poliovirus (it was, and is, a scourge that killed and disabled many tens of thousands of people), but rather to elevate the status of those who contracted the disease and then persevered in spite of their physical limitations. This positive rehabilitation spirit sent a strong message to the women and men working at that time in the young profession of physical therapy. It is an interesting twist of fate that some of the same patients who greatly influenced the profession over a half-century ago have been seeking treatment from subsequent generations of physical therapists, many of whom may know little about the epidemic. I hope this historical perspective has helped to fill some of the gaps.

In closing, perhaps my strongest motive for writing this perspective was to take the opportunity to showcase the dedicated physical therapists who worked during the polio epidemic. Although I highlighted the more prominent therapists of the time, I also want to recognize the efforts of the thousands of staff therapists whose names never made it to print. The physical therapists of the day not only rose to the challenge, but learned from it; their robust and optimistic response ultimately accelerated the growth of the profession. My hope is that these efforts will not be forgotten as physical therapy continues its forward progression.

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Web Sites on Franklin D. Roosevelt and Polio

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<http://www.ipl.org/div/potus/fdroosevelt.html>