Clinical Impact and Evidence Base for Physiotherapy in Treating Childhood Chronic Pain

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ABSTRACT

Purpose: As part of the special series on pain, our objectives are to describe the key features of chronic pain in children, present the rationale for interdisciplinary treatment, report a case study based on our biopsychosocial approach, and highlight the integral role of physiotherapy in reducing children's pain and improving function. We also evaluate the evidence base supporting physiotherapy for treating chronic neuropathic pain in children.

Summary of Key Points: Chronic pain affects many children and adolescents. Certain challenging pain conditions begin primarily during adolescence and disproportionately affect girls and women. Children with these conditions require an interdisciplinary treatment programme that includes physiotherapy as well as medication and/or psychological intervention. Converging lines of evidence from cohort follow-up studies, retrospective chart reviews, and one randomized controlled trial support the effectiveness of physiotherapy within an interdisciplinary programme for treating children with chronic pain.

Conclusions: Evidence-based practice dictates that health care providers adopt clear guidelines for determining when treatments are effective and for identifying children for whom such treatments are most effective. Thus, additional well-designed trials are required to better identify the specific physiotherapy modalities that are most important in improving children's pain and function.

Key Words: biopsychosocial, evidence base for physiotherapy in treating chronic pain, interdisciplinary, inter-professional, paediatric chronic pain management, paediatric complex regional pain syndrome (CRPS), paediatric neuropathic pain, paediatric physiotherapy

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RÉSUMÉ

Objectif : Dans le cadre d'une série spéciale sur la douleur, nos objectifs étaient de décrire les principales caractéristiques de la douleur chronique chez les enfants, de présenter l'argumentaire favorisant un traitement multidisciplinaire, de préparer un rapport sur une étude de cas reposant sur notre approche biopsychosociale et de souligner le rôle global de la physiothérapie pour réduire la douleur et améliorer la fonction des enfants. Nous évaluons également les faits scientifiques appuyant le recours à la physiothérapie pour le traitement de la douleur neuropathique chronique chez les enfants.

Résumé des principaux points : La douleur chronique touche de nombreux enfants et adolescents. Certains états douloureux particulièrement difficiles voient le jour principalement au cours de l'adolescence et touchent les filles et les femmes de manière disproportionnée. Les enfants aux prises avec un tel problème ont besoin d'un programme de traitement multidisciplinaire incluant de la physiothérapie, de même que des médicaments et/ou une intervention en psychologie. Des preuves convergentes issues du suivi de cohortes à la suite d'études, d'analyse rétrospective de dossiers et d'une étude randomisée contrôlée appuient l'efficacité de la physiothérapie dans le cadre d'un programme multidisciplinaire pour le traitement de la douleur chronique chez les enfants.

Conclusions : La pratique fondée sur l'expérience clinique presse les fournisseurs de soins de santé à adopter des lignes directrices claires pour déterminer quand des traitements sont efficaces, et pour identifier chez quels enfants de tels traitements sont efficaces. En conséquence, des études supplémentaires adéquatement conçues seront nécessaires pour mieux identifier les modalités spécifiques à la physiothérapie qui seront les plus importantes pour améliorer la fonction et réduire la douleur des enfants touchés.

Mots clés : biopsychosocial, gestion de la douleur chronique pédiatrique, interprofessionnel, multidisciplinaire, physiothérapie pédiatrique, preuves scientifiques de la physiothérapie pour le traitement de la douleur chronique, syndrome douloureux régional complexe (SDRC) pédiatrique

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INTRODUCTION

During the last two decades, unprecedented attention has focused on the unique pain problems of infants, children, and adolescents, as evidenced by the increase in clinical and basic research.^{1–3} Previously, clinical decisions about whether children were experiencing pain and, if so, about the particular pain therapies required were based primarily on personal beliefs rather than on scientific evidence.^{4–8} Regrettably, the common *misbelief* that children did not feel pain as intensely as adults, and consequently did not require similar analgesics—as well as pervasive fears that children were at heightened risk of opioid addiction and should receive minimal analgesic doses—caused many children to suffer needlessly.^{4,9–12}

Through extensive research, we now have enhanced insights into how the developing nociceptive system responds to tissue injury, how to assess pain in infants and children, how children perceive pain, and which therapies should alleviate their acute pains, as documented in a historical review of the paediatric pain field¹³ and a recent review of infant pain management.³ The emphasis in assessment and treatment has gradually shifted “from an almost exclusively disease-centered focus—detecting and treating the putative source of tissue damage—to a more child-centered perspective, assessing the child with pain, identifying contributing psychological and contextual factors, and then targeting drug and nondrug interventions accordingly.”^{13(p.442)} We have long recognized that optimal pain management requires treating children from a broader biopsychosocial perspective.^{14–16} This is especially relevant when treating a child with chronic pain.^{17–19}

In this article, we highlight some of the unique features of chronic pain in children that necessitate a biopsychosocial treatment approach. We then describe the unique responsibilities of a physiotherapist in an interprofessional paediatric pain clinic by presenting a case study illustrating our multimodal treatment approach and effective strategies for decreasing children’s pain and pain-related disability. We conclude by reviewing the scientific evidence for the role of physiotherapy in treating children’s chronic pain.

Children with Chronic Pain

Like adults, children can develop chronic pain as a result of injury, disease, psychological factors, or unidentified aetiologies. Available epidemiological data indicates that chronic pain affects many children and adolescents.^{20–22} The prevalence of childhood chronic pain increases with age, and certain conditions, such as migraine headaches and complex regional pain syndrome—Type I (CRPS-I), disproportionately affect girls.²³

Chronic pain was traditionally regarded as any pain problem persisting beyond the usual period required for

an injury to heal, or any pain lasting longer than 3 months. However, much basic research has demonstrated that the term “chronic” represents more than a temporal dimension: it usually indicates that the neural mechanisms underlying pain are different from those involved in acute pain (i.e., those involved when the nociceptive system responds normally to stimulation). For example, a peripheral injury evokes acute pain through activation of intact peripheral nociceptors; pain subsides when the stimulation ends. In contrast, chronic pain often has neuropathic components wherein nerves are injured and respond abnormally to normal sensory stimuli. (See Sluka^{24,25} and Fields, Basbaum, and Heinreicher²⁶ for reviews of the peripheral and central mechanisms involved in pain processing.) Pain may persist, or intensify, even though there is no evidence of continuing injury.

Although the vast majority of research on chronic pain and neuropathic mechanisms has involved adults, increasing attention has focused on infants and children. Basic research on animal models and clinical research with infants has shown that the developing nociceptive system’s responses to injury differ from those of the mature adult system, showing increased excitability and sensitization in response to tissue damage (for reviews see Fitzgerald and Walker³ and Andrews²⁷).

Because the immature nociceptive system has larger receptive fields and dominant A-fibre input, there is an increased likelihood that central cells will be excited by peripheral sensory stimulation; thus, infant sensory reflexes are more sensitive to stimulation. Moreover, descending inhibitory mechanisms are not functional at birth,²⁸ meaning that an important endogenous analgesic system is lacking, and noxious input may affect neonates more negatively than it would affect adults. The immaturity of synaptic connections and integrated circuitry in the newborn means that the infant pain experience is more diffuse and less spatially focused than that of adults. Since the newborn system is also under less endogenous control, painful stimulation may evoke a more powerful neural response, as documented in a recent review of the developmental neurobiology of infant pain.³

Children also differ from adults in that their pain perception seems relatively more plastic or modifiable.^{13,29} We do not know whether such plasticity is due to developmental differences in neurobiology; differences in the length of the patient’s experience of chronic pain (potentially shorter for children), which may be more modifiable in the earlier “chronic” stages; or differences in children’s ability to activate descending inhibitory pathways.

Comparable basic research has not yet been conducted on the adolescent system, a unique developmental stage. Adolescence appears to be a vulnerable period with respect to chronic pain, in that certain pain condi-

tions begin primarily during this period.^{20,23,30} Girls are apparently more at risk of developing certain disabling conditions such as CRPS-I.³¹ (Features of this syndrome are described later in this article, in the context of a case report of a child with CRPS-I.)

Rationale for Interdisciplinary Treatment

We have long recognized that in order to treat chronic pain adequately, health care providers must evaluate the primary sources of pain and ascertain whether environmental, behavioural, and psychological factors are contributing to children's pain or pain-related disability.³²

Treatment emphasis has shifted from an exclusively disease-centred framework to a broader child-centred focus. Health care providers should select specific therapies to target the responsible peripheral and central mechanisms and also therapies to mitigate the pain-intensifying impact of the behavioural and psychological factors that are usually present. Drug therapies include analgesics such as acetaminophen, non-steroidal anti-inflammatory drugs, opioids, and adjuvant analgesics.^{33–35} The latter are a variety of drugs with analgesic properties that were initially developed to treat other health problems, such as anticonvulsants (e.g., gabapentin) and antidepressants (e.g., amitriptyline).³⁶ The use of adjuvant analgesics has become a cornerstone of pain control in paediatric chronic pain, and these therapies are especially crucial when pain has a neuropathic component. (For a recent review of medication used for pain control in children, see Brown, Taddio and McGrath.³³)

Irrespective of aetiology, chronic pain has profound and prolonged physical, behavioural, and psychological consequences for children and their families.^{37–40} Pain adversely affects all aspects of children's lives, causing major disruptions to their normal activities and relationships. Children usually have some pain-related functional impairment, as a consequence of protecting the painful region because of a fear that their pain will increase with use.^{29,41} They may thus become progressively more physically disabled as they increasingly avoid using a painful arm or bearing weight on a painful ankle. Parents may inadvertently reinforce disability behaviours through their own fears that any increase in pain (e.g., when children try to resume an activity) signifies further damage.^{18,29}

Naturally, parents first evaluate children's pain through their own understanding of pain—typically, from the perspective of acute injury, where pain is related to tissue damage, has a single cause, and can be cured by a single treatment.¹⁷ They do not understand that, unlike most acute pains their children may have already experienced, chronic pain may not serve a useful purpose and may have several interrelated causes. Parents thus continue medical investigations as they search for the one definite physical aetiology responsible for their child's

pain. They believe that through these investigations they will eventually receive a prescription for a treatment that will immediately stop the pain. In our experience, both children and parents often expect that they will remain disabled until the “one right treatment” is found and that they have no ability to change the future course of continuing pain and disability.⁴²

Parents' and children's beliefs about causes of pain and probable long-term prognoses guide their behaviours and shape their emotional responses. Health care providers must therefore evaluate the child with chronic pain within the broader family context to ensure that they can appraise and, if necessary, address any family beliefs and behaviours that might impede the child's recovery. Controlling children's chronic pain requires an integrated team approach because health care providers must assess the many factors responsible for children's pain and disability.

The use and effectiveness of inter-professional teams in treating children with chronic pain has been well described in the paediatric pain literature.^{43–47} A recent survey of interdisciplinary pain-treatment programmes in Canada revealed that teams were staffed with a minimum of three different health care providers, such as physicians, nurses, and psychologists.⁴⁸ Physiotherapists were the most common non-physician team member, included in 75% of pain programmes.⁴⁸ With their substantial training in pain mechanisms and management within a framework of rehabilitative medicine, physiotherapists are ideally suited to assess children's functional impairments. Moreover, physiotherapists provide unique disciplinary expertise to complement specialized medical, nursing, psychology, and psychiatric health care providers in developing and implementing a rehabilitative treatment programme for children with chronic pain. The following case report demonstrates the integration of pharmacological, psychological, and physical therapies in treating a child with neuropathic pain. In our clinic we refer to “the 3 Ps” to emphasize to families the importance of each treatment component.

CASE STUDY: CHRONIC PAIN AND DISABILITY AFTER INJURY

Lucy (a pseudonym), a 10½-year-old girl, presented at the Emergency Department (ED) with complaints of intense, sharp pain in her right foot after twisting her ankle in a friendly schoolyard basketball game earlier in the day. Her right foot and toes were moderately swollen; her skin temperature was cool, and skin colour was purplish and mottled. Lucy could not move her right foot or ankle and could not bear weight on her right leg. X-rays at the time were described as normal. Lucy had made several visits to the ED in the prior 2 months with complaints of right ankle pain (related to what were felt to be soft-tissues injuries incurred through gymnastics) and

had been diagnosed with a possible sprain. Based on her current physical symptoms and history, the ED physician diagnosed Lucy with CRPS-I and referred her for physiotherapy.

CRPS-I, previously known as Reflex Sympathetic Dystrophy (RSD), is a peripheral neuropathic pain condition with an autonomic component that occurs after a trauma (such as a fracture, sprain, or surgical procedure) to the distal part of an extremity. In adults and children, CRPS-I is most often associated with distal extremity pain and swelling and with pain that seems disproportionate to the injury. Physical signs can include sensory disturbances, notably allodynia and hyperalgesia, and sensitivity to cold. Typical autonomic abnormalities are swelling, increased sweating, changes in skin colour, and temperature differences between limbs. Trophic changes, such as abnormal nail and hair growth, shiny skin, and osteoporosis, are often evident. Motor findings of loss of range of motion, weakness, tremor, and functional motor disturbances are frequently present.^{31,41,49}

Lucy had a physiotherapy assessment 3 days after her ED visit. In order to establish a positive rapport with Lucy, the physiotherapist first asked her to sit comfortably in a regular chair, rather than conducting the clinical interview while Lucy lay on the examination table. The physiotherapist also spoke directly with Lucy to increase her comfort level, rather than obtaining information mainly from her accompanying parent. Lucy reviewed her pain history and described the abnormal sensitivity she was now experiencing in her foot. Following the clinical interview, the physical examination revealed extensive allodynia throughout Lucy's right lower extremity in a sock-like distribution extending from the tips of the toes to a mid-calf height circumferentially (see Figure 1, Week 1). Lucy demonstrated protective posturing (i.e., no weight bearing) of her right lower extremity when sitting, standing, and ambulating with two crutches. She exhibited muscle atrophy in her right calf, with a 1 cm decrease in the girth measurement compared to her left side. She had no active range of motion (AROM) in her right foot or ankle joints.

Figure 1 Foot images

Lucy had significant pain-related disabilities. She could not wear a sock or shoe on her right foot, because the pressure increased her pain to an intolerable level. She was unable to sleep at night because she woke when the sheets even lightly touched her sensitive right foot. She had withdrawn from her usual recreational activities (tae kwon do, skating, and basketball), and had difficulty attending school and concentrating in class because of her pain level and her fear of unpredictable bouts of severe pain.

Based on a physiotherapy appraisal, Lucy's problems included abnormal sensory disturbances in her right lower leg; protective posturing of the right leg, resulting in asymmetry in her static and dynamic activities; absent AROM of the ankle and foot; an abnormal gait pattern, with a need for mobility aids; altered school participation and attendance; withdrawal from peer-related sports and activities; and an increased dependence on her mother for assistance in activities of daily living.

Factors That Affect Chronic Pain and Disability

Lucy also received a psychological consultation to identify relevant psychosocial factors that could be contributing to her pain and disability, as listed in the model shown in Figure 2. The team psychologist uses this model to explain to the child and parent how interactions between cognitive, behavioural, and emotional factors adversely affect children's pain and disability. While some factors are relatively stable for a child, such as gender, temperament, and cultural background, other factors change progressively, such as age, cognitive level, previous pain experience, and family learning (listed in the lower open box in Figure 2). These child characteristics shape how children generally interpret and experience different types of pain. In comparison, the cognitive, behavioural, and emotional factors (listed in the upper shaded boxes) vary from child to child and represent a unique interaction between the child and the situation in which pain is experienced.^{14,15} What children (and parents) know, do, and feel exerts a profound impact on their subsequent pain and disability. The bulleted cognitive, behavioural, and emotional factors were identified from Lucy's psychological and pain team assessments.

Treatment Programme: Desensitization and Rehabilitative Exercise

As in many cases of paediatric chronic pain, the factors contributing to Lucy's neuropathic pain were multiple and interwoven, encompassing physical abnormalities and symptoms as well as psychosocial factors. Following standardized inter-professional team clinical assessment, Lucy received an individualized rehabilitative treatment regimen that included an adjuvant analgesic prescribed by the team's pain physician, cognitive-

Figure 2 Factors that affect chronic pain and disability

behavioural therapy provided by the team psychologist, and physiotherapy. Physiotherapy treatment goals were to restore normal function within a broader biopsychosocial context. Lucy's primary goals were to walk without crutches and to resume physical activities with her friends without provoking episodes of severe pain. Her goals enabled the physiotherapist to build a therapy programme based on "Lucy's wants," including age-appropriate and clear expectations for Lucy to be very active in therapy and in achieving her functional goals. The explicit focus was shifted away from her pain (which was expected to lessen with the physiotherapy and medication) and toward regaining function in a progressive and feasible therapy plan, consistent with principles of chronic pain management.^{50,51}

Lucy's physiotherapy programme included weekly therapy sessions in clinic (usually 1 hour in length) and daily exercises to complete at home. Each clinic session began with "the plan for the day"—a brief description and explanation of the purpose of the session's activities—so that Lucy could have clear expectations of what was to come during the visit. The physiotherapist encouraged and praised Lucy throughout the session and concluded by explaining Lucy's homework exercises. Not surprisingly, Lucy's parents had difficulty watching Lucy during therapy, especially when she complained that the therapy was causing increased pain. The physiotherapist asked Lucy's parents to help support Lucy by expecting her to adhere to physiotherapy regime

and promoting her normal behaviours, despite occasional escalations of pain during exercise or daily activity. It was stressed that, in this instance, *exercise-induced* pain was a sign of restoring function to damaged nerves, not a sign of further damage.^{52,53}

Physiotherapists must express confidence in their application of such a treatment programme, which often includes the expectation that children will experience increased pain during exercises, while also gently shifting the child's and parents' overall beliefs about managing pain in their daily lives (e.g., reducing protective behaviours, increasing awareness of posturing). In this case, the physiotherapist served as a coach to Lucy, encouraging and providing direction to her during exercises and reminding her of the overall purpose of "in-therapy" exercise-induced pain, in the context of a larger interdisciplinary treatment programme.⁵³

Lucy's progressive rehabilitative programme had two main components: desensitization techniques to restore normal sensitivity and exercises to increase range of motion and weight bearing. Desensitization techniques included varied exercises to enable Lucy to increasingly tolerate the feel of different tactile and thermal sensations on her affected foot. Lucy gradually applied different textures to her affected skin, progressively increasing the roughness of the materials and the area of contact on her foot. She used contrast baths (increasingly different water temperatures between hot and cold) and started brief but frequent periods of self-massage. As she could

tolerate more stimulation on her foot, she began to wear socks and her shoe for brief periods of time. Needless to say, the start of desensitization is difficult for children, as they experience increased discomfort during the application of sensory techniques. The physiotherapist plays an important role in coaching the child to participate in a regular, progressive desensitization programme to address the symptoms of allodynia.^{41,49,54,55}

The importance of attending sessions as well as of adhering to the programme of daily at-home exercises, including desensitization, must also be stressed with families. Like many children, Lucy had particular trouble in completing exercises at home and required consistent parental support and assistance. In general, parental presence and support have long been identified as key factors affecting children's pain management.⁵⁶ In our experience, parental *attitude*—specifically, beliefs about pain as an indication of further damage for children with CRPS-I—is the most critical factor, since parents directly control children's treatment options. Lucy's mother initially had difficulty in supporting her daughter during either hospital-based or home-based exercises, as she believed that any pain Lucy felt during physical therapy meant that she was further damaging her foot. During hospital sessions, therefore, Lucy's mother was encouraged to wait in the reception area rather than accompanying her daughter into the treatment room. This allowed Lucy the best chance to complete exercises with the physiotherapist's coaching and support of her efforts. It was expected that Lucy's success with the physiotherapist (despite in-session pain) would transfer to increased adherence at home.

The second component of treatment focused on restoring normal functioning. The physiotherapist integrated progressive weight-bearing tasks, postural training, and AROM and strengthening exercises into varied activities that were fun and challenging for Lucy. Focusing on a positive activity helps to minimize children's pain during therapy and increase their time on task. Therapy progressed from tasks that Lucy could complete easily while sitting to tasks that required her to stand and bear some weight on her affected foot. Tasks included squishing a cotton ball with her right foot, picking up a marble in a basin of lukewarm water, footprint painting, statue stances while tossing a ball at a target, and Wii Fit balance games. Lucy became tense and overwhelmed if she found a task too challenging or painful, so the physiotherapist taught her how to use some simple relaxation techniques, such as pursed-lip breathing and imagery, and incorporated distraction activities, such as listening to music on an iPod. It should be noted that a trial of transcutaneous electrical nerve stimulation (TENS) was recommended as an additional approach to assist in the management of limb pain and allodynia by closing the pain gate to noxious stimuli;^{45,49,57–59} however, Lucy declined the use of this electrotherapy modality, preferring alternative pain-control techniques.

Figure 3 Physiotherapy outcome measurements

Lucy's progress throughout her programme over 13 weeks is summarized in Figures 1 and 3. By the end of the programme, as shown in Figure 3, she had full AROM in her ankle joint (Figure 3a), was walking independently without any aids (Figure 3b), and rated her pain as minimal (Figure 3c). Lucy's skin sensation gradually normalized in her right leg (see progression over weeks 1, 5, and 10 in Figure 1), with complete resolution of abnormal sensations by week 13 (not shown). After 13 weeks of physiotherapy intervention, in conjunction with her medication and a psychological consultation, Lucy had returned to school full time with good attendance. She was able to join her friends in the schoolyard at recess, and she began to attend tae kwon do classes twice weekly. Overall, the cheerful, carefree, and active young Lucy had returned.

This case illustrates the focus of physiotherapy inter-

ventions adhering to a child- and family-centred model of care. The emphasis of therapy is on restoring function to the child's daily life, with secondary acknowledgement of pain. Physiotherapy is needed in a direct, supervised setting, with continuation of exercises at home in a regular, defined manner. The systematic assessment of outcomes is essential for modality evaluations and progression toward patient goals.

THE EVIDENCE BASE FOR PHYSIOTHERAPY FOR CHILDREN WITH COMPLEX CHRONIC PAIN

The scientific evidence supporting any drug or non-drug therapy in clinical practice is based on an objective evaluation of the type and quality of studies that have been conducted to evaluate that particular therapy. After reviewing all studies conducted to evaluate a particular therapy, an expert panel classifies the body of evidence that support its effectiveness. Standardized rating systems include numerical ratings and terms such as *excellent*, *good*, and *poor* to indicate the strength of scientific evidence. Clinical practice guidelines in pain rate the strongest evidence base as Level Ia, derived from meta-analysis of randomized controlled trials (RCTs). Scientific strength decreases progressively through Level Ib (evidence obtained from at least one RCT), Level IIa (evidence obtained from at least one well-designed controlled study without randomization), Level IIb (evidence from at least one other type of well-designed quasi-experimental study), and Level III (evidence obtained from well-designed non-experimental studies such as comparative, correlational, and case studies) to Level IV (evidence obtained from clinical experience of respected authorities and/or expert committee reports).⁶⁰

Systematic Reviews

Evidence for the effectiveness of physiotherapy in treating neuropathic pain is limited, especially from high-quality RCTs. Sluka⁴⁹ concludes that there is moderate evidence from controlled trials with adults to support the use of exercise for treatment of CRPS, good evidence to support the use of TENS and mirror-image therapy, and limited evidence to support the use of sensory re-education. A recent systematic review on the effectiveness of physiotherapy to manage adult CRPS-I evaluated 1,320 potential articles.⁶¹ The authors identified only 14 articles that met their inclusion criteria: were written in English, were conducted between 1987 and 2007, studied the outcome of physiotherapy alone or in combination with medical or psychological therapies, stated diagnostic criteria based on clinical presentation, and included a quantitative study design (i.e., RCTs, non-randomized clinical trials, or case series). Again, there was insufficient evidence to provide high-level support for many common modalities used in physiotherapy. Nonetheless, the authors concluded that

there was varying evidence for a few modalities, such as graded motor imagery combined with medication (rated as very good quality),⁶² graded-exposure in vivo programme (rated as good quality emerging),⁶³ and sensorimotor treatment (rated as fair quality emerging).⁶⁴

Smith⁵⁸ also reviewed the literature on the efficacy of physiotherapy in treating CRPS-I in adults and children. The search identified 748 potential citations. Articles included were those written in English with studies of human participants, excluding case reports, abstracts, letters, comments, editorials, and review articles. Only 25 articles met the selection criteria for further review, 5 of which focused on children. Smith concluded that some physiotherapy interventions may assist in the management of adult and childhood CRPS-I but that limited research and methodological shortcomings prevented a clear determination of the effectiveness of individual treatments.

Literature Review

Despite the recognized importance of physiotherapy in treating children with chronic neuropathic pain, including CRPS-I, relatively little research has been conducted to document treatment effects or to evaluate different therapeutic techniques. We searched electronic bibliographic databases (Medline, CINAHL, OVID, PubMed) using the keywords *neuropathic pain*, *children*, *physiotherapy*, and *CRPS* to identify relevant articles. We then reviewed 372 potential articles and identified 65 English-language articles in which authors reported data on the effect of physiotherapy on children's pain, function, or disability. Only seven studies explicitly evaluated the role of physiotherapy in treating children with neuropathic pain. The majority of studies ($n = 33$) were case reports, describing treatment outcomes either for a single patient ($n = 19$) or for a small series of patients ($n = 14$). Physiotherapy was a primary component of interdisciplinary care in 19 studies, while analgesic/anaesthetic intervention was the primary component in 14 reports. All case studies indicated that children improved with respect to pain and/or function. A further 12 articles were reviews, commentaries, or practice guidelines on assessing or treating children with chronic or neuropathic pain. The remainder were incorrectly identified and related to management of specific diseases or to adult populations.

The seven studies that evaluated the role of physiotherapy for treating paediatric neuropathic pain included children and adolescents diagnosed primarily with CRPS. In all studies, physiotherapy was assessed as part of an interdisciplinary programme, usually including education, medication, and/or psychological intervention. Physiotherapy programmes were individualized and based on a child's physical condition, so children within the same study varied with respect to the specific physiotherapy modalities they received. Table 1 summarizes

Table 1 Summary of Studies Including Physiotherapy for Children with CRPS (Presented in Order of Increasing Scientific Strength)

Study	Type	Sample	Physiotherapy	Pharmacological	Psychological	Outcomes
Wesdock (1991) ⁶⁶	Chart review (1940–Jun 1989)	<i>n</i> = 36 (F = 24, M = 12) Age: 8–19 years (mean: 13.4 years) Duration: * 1–53 months (mean: 9.4 months; median: 4.2 months)	Majority received physiotherapy (<i>n</i> = 34), including active exercise, passive exercise, TENS, cryotherapy, splinting, pressure, desensitization, heat, sound waves, biofeedback, contrast baths (presented in order of decreasing frequency)	Wide range of systemic medications (<i>n</i> = 32), including injections (<i>n</i> = 7) and blocks (<i>n</i> = 6)	Psychological evaluation (<i>n</i> = 30) Majority received informal counselling by physical therapist	Full resolution of first RSD episode (<i>n</i> = 25) in 9 months No link was identified between successful outcomes and any one PT modality or group of modalities. Beneficial components included progressive tactile and pressure desensitization, cold or hot packs, graduated weight bearing, and walking in a pool.
Kesler (1988) ⁵⁷	Prospective follow-up (Dec 1980–Jul 1986)	<i>n</i> = 10 (F = 9, M = 1) Age: 8–18 years (mean: 12.9 years) Duration: * 2 days–24 months (median: 5 months)	All patients received physiotherapy instruction, home-based exercise and TENS.	Analgesics and/or anti-inflammatory agents (<i>n</i> = 5) or blocks (<i>n</i> = 3)	None	Complete resolution in 2 months (<i>n</i> = 7) or 36 months (<i>n</i> = 1)
Low (2007) ⁶⁵	Chart review (Jan 2001–Dec 2004)	<i>n</i> = 20 (F = 18, M = 2) Age: 8–16 years (mean 11.8 years) Duration: * 2 days–41 weeks (mean: 13.6 weeks)	All patients received physiotherapy, including graded exercise programme, ROM, hydrotherapy, massage, desensitization.	Most patients received simple analgesia and adjuvant analgesics—amitriptyline or gabapentin (<i>n</i> = 14).	Psychological evaluation and intervention (<i>n</i> = 18), including pain and stress management skill building	Full resolution of symptoms for patients receiving “3 Ps” approach (<i>n</i> = 12) or PT and CBT combination (<i>n</i> = 4) in 3 days to 64 weeks
Kachko (2008) ⁶⁷	Chart review (2003–2005)	<i>n</i> = 14 (F = 10, M = 4) Age: 7–16 years (mean: 11.8 years) Duration: * 0.3–1.8 years	All patients received intensive program of four 2-hour sessions per week plus twice-daily home exercises.	Amitriptyline (<i>n</i> = 13) or carbamazepine (<i>n</i> = 1) plus additional medications (<i>n</i> = 4) Various invasive treatments (<i>n</i> = 4), including blocks	CBT (<i>n</i> = 11), including guided imagery, biofeedback, and relaxation techniques	Full (<i>n</i> = 11) or partial (<i>n</i> = 2) recovery in 2–28 weeks (mean: 8 weeks) Majority of patients (<i>n</i> = 10) had reduced pain and improved function with non-invasive drug and rehabilitation treatment approach
Sherry (1999) ⁵⁵	Prospective follow-up (Jul 1984–Feb 1997)	<i>n</i> = 103 (F = 87, M = 16) Age: 7–21 years (mean: 12.7 years) Duration: * 1–108 months (median: 2 months)	All patients received daily intense exercise (5–6 hours), including aerobic exercise, functional directed exercise, hydrotherapy (1–2 hours), desensitization, and home exercise program (45 minutes–3 hours).	None (occasional acetaminophen for headache; all other medications discontinued)	Psychological evaluation, followed by referral to psychotherapy for majority of patients (<i>n</i> = 79)	Complete resolution of pain and full function (<i>n</i> = 95) in 1–90 days (mean: 6–14 days) Intense physical treatment was associated with a low rate of long-term symptoms and dysfunction.

(Continued)

Table 1 (Continued)

Study	Type	Sample	Intervention			Outcomes
			Physiotherapy	Pharmacological	Psychological	
Wilder (1992) ³¹	Chart review (Feb 1986–Jun 1989)	<i>n</i> = 70 (F = 59, M = 11) Age: 5–17 years (mean: 12.5 years) Duration: * range not specified (mean: 12 months)	All patients received physiotherapy, including TENS, desensitization, heat, whirlpool, and PROM.	NSAIDS, tricyclic antidepressants Sympathetic blocks and adjuvant analgesics when unresponsive to conservative approach	All patients received a psychological evaluation, and the majority were offered behavioural therapy for relaxation training and/or biofeedback.	Perceived positive response to PT treatment (<i>n</i> = 44) and CBT (<i>n</i> = 25) at first follow-up (mean duration: 3 years) Highly variable response rates to medications and blocks
Lee (2002) ⁶⁸	Randomized controlled trial (Oct 1997–Jan 2001)	<i>n</i> = 28 (F = 26, M = 2) Age: 8–17 years (mean: 12.8 years) Duration: * 1–18 months	All patients randomized to 6 weeks of either one 1-hour session or three 1-hour sessions per week of physiotherapy, including TENS, weight bearing, massage, desensitization, and contrast baths	None reported	6 weekly CBT sessions (<i>n</i> = 28), including deep breathing, relaxation, biofeedback, and guided imagery	Reduced symptoms and pain and improved function for all participants at first follow-up (6–25 weeks) and maintenance or additional improvements at long-term phone follow-up (29–158 weeks) No difference between physiotherapy groups

CBT = cognitive-behavioural therapy; NSAIDS = non-steroidal anti-inflammatory drugs; PROM = passive range of motion; ROM = range of motion; RSD = Reflex Sympathetic Dystrophy; TENS = transcutaneous electrical nerve stimulation
 * Duration of pain prior to assessment and/or treatment initiation.

the sample description, treatment approaches by discipline (physiotherapy, pharmacological, and psychological), and outcomes for each study; we review the key features, similarities, and discrepancies among these seven studies below.

Almost all of these studies were either retrospective chart reviews or prospective follow-ups of children treated in hospitals or at specialized pain clinics. In each study, physiotherapy programmes encompassed a wide range of rehabilitative modalities, such as progressive exercise, hydrotherapy, biofeedback, and desensitization. The method by which therapeutic effects were assessed also varied, but typical assessment included an appraisal of improvements in function, physical signs, and neuropathic pain symptoms. While all studies indicate that between 67% and 100% of children improved after treatment, it is difficult to compare results across studies because of their differing outcome indices and the range of follow-up periods. Nonetheless, despite methodological differences, a consistent pattern highlighting the clinical impact of physiotherapy emerges across diverse pain centres and countries (the United States, Australia, and Israel).

The children and adolescents in different studies varied widely in age, from 5 to 18 years old. However, the mean age and age range for the different clinical cohorts are comparable across studies, suggesting a higher prevalence of CRPS-I in pre- or early adolescence. Low et al.,⁶⁵ Wilder et al.,³¹ and Wesdock et al.⁶⁶ also reported the prevalence distribution by age, but no clear pattern is apparent. Although sample sizes were often small, all studies showed a comparably higher prevalence for girls, with female:male ratios ranging from 2:1 to 13:1 (with an average ratio of 5:1). Children also varied widely with respect to how long they had had CRPS prior to assessment or to starting appropriate treatment, from 2 days⁵⁷ to 9 years.⁵⁵ Recent demographic data on 70 children from our Canadian study of children with CRPS-I (prospective data collected between 2004 and 2009) reveal a similar mean age of onset of 11.8 years (rang: 5.8–17.6 years); a 6:1 female: male ratio has been noted (McGrath et al., unpublished observations).

Wesdock et al.⁶⁶ reviewed cases of children with RSD who were treated at the Alfred I. DuPont Institute in Delaware over a span of nearly 50 years. Almost all children (34/36) received physical therapy; a similar proportion received varied medication regimens and psychological assessments. Treatment outcomes varied: 15 children resolved fully, 8 had recurrences of RSD, 9 continued to have RSD, and 4 were lost to follow-up.

Kesler et al.⁵⁷ followed a clinical cohort of 10 children who had been treated at the University of Virginia Medical Center during the previous 6 years. All children initially received TENS and home-based physiotherapy. Seven children had complete remission within 1 month,

two children showed some improvement, and one child did not improve. However, three children also received regional anaesthetic blocks. Low et al.⁶⁵ reviewed medical records for the 20 children treated at the Children's Hospital at Westmead, Australia, from 2001 through 2004. Children received an intensive outpatient physiotherapy programme, medication, and psychological therapy, and a subset of children received in-patient programmes. The majority of children ($n = 8$) showed full resolution of all signs and symptoms within 4 months (mean: 15.4 weeks; range: 3 days–1.25 years). Four children had a recurrence of CRPS.

More recently, Kachko et al.⁶⁷ reviewed charts for all children referred for CRPS treatment at Schneider Children's Medical Center of Israel during a 3-year period. Fourteen children were diagnosed with CRPS (types I and II) and treated with intensive physiotherapy as well as cognitive-behavioural therapy (CBT) and medication. Most children experienced reduced pain and improved function within 2 months, but four children required regional anaesthetic blocks, and four experienced a recurrence of CRPS.

Two larger cohorts of children with CRPS have also been studied. Sherry et al.⁵⁵ followed 103 children with CRPS who had been treated in an exercise programme at the Children's Hospital and Medical Center, Seattle, from 1984 to 1997. The therapy programme focused on restoring function almost exclusively through aerobic exercise training rather than progressive, functional exercises. Children received 5 to 6 hours of therapy daily with occupational and physical therapists, 1 to 2 hours of hydrotherapy, and daily home exercises. After completing the programme (mean duration; 14 days; range: 1–90 days), the majority of patients (92%) experienced a complete resolution of symptoms and return to full function. Long-term follow-up of approximately half of these patients indicated that 88% had no symptoms of CRPS; no follow-up was available for the other half of the sample. Psychological evaluation was completed on all children, and the majority were referred for psychological treatment. The authors were unable to report on the extent to which psychological therapy may have contributed to treatment outcomes. Children in this cohort had a CRPS recurrence rate of 31%.

Wilder et al.³¹ followed 70 children and adolescents with RSD who had been treated by the Pain Service at Children's Hospital, Boston, between 1986 and 1989. Children were treated according to a consistent algorithm, beginning with physical therapy, TENS, and psychological assessment (which led to CBT for more than half the group). Most children received a trial of simple analgesics. If they did not improve, adjuvant analgesics (e.g., tricyclic antidepressants) were provided, followed by a possible trial of sympathetic blocks or other medications (e.g., anticonvulsants).

RCTs are the gold standard for evaluating therapies in

evidence-based practice; however, only one RCT has been conducted on the efficacy of physiotherapy for children with chronic neuropathic pain. Lee et al.⁶⁸ randomized 28 children to receive physiotherapy either once weekly or three times weekly for a 6-week period. All physiotherapy programmes were individualized for each child, with specific modalities based on the child's status and complexity. All children were prescribed home exercises in addition to the clinic sessions. Children also received six weekly sessions of CBT and a standardized education programme. Thus, the primary difference between physiotherapy treatment groups was a weekly versus three-times-weekly therapy session conducted with a physiotherapist in the clinic. Physiotherapists assigned daily homework for all children and set specific treatment goals. Compliance was good; 79% of children attended at least 80% of physiotherapy sessions. Three children dropped out of the trial; all remaining children had improved significantly at short-term follow-up (6–25 weeks after randomization; mean: 10 weeks), regardless of which physiotherapy treatment they received. Children reported less pain (median VAS value decreased from 6.4/10 to 0.6/10), as well as less gait impairment and improvements in stair-climbing ability (from 9.0/15 to 0.05/15 and from 9.0/15 to 1.0/15, respectively, where higher scores indicate more impairment). The authors were unable to analyze compliance with homework because of children's failure to record information, and therefore could not determine whether children who saw the therapist more frequently were more compliant in completing home exercise or were more easily able to achieve their treatment goals during the 6-week treatment period. An end-of-study phone interview (between 29 and 180 weeks after treatment) revealed no long-term differences between treatment groups, but the authors reported that CRPS recurred in approximately 50% of children.

CONCLUSIONS AND RECOMMENDATIONS

Evidence-based practice dictates that health care providers adopt clear guidelines for determining when treatments are effective and for identifying children for whom such treatments are most effective. Yet we lack data from well-designed cohort studies and RCTs to support the efficacy of many of the drug and non-drug therapies used extensively in clinical practice to treat children with chronic pain.^{13,69–72}

As reviewed above, the evidential support for physiotherapy as a critical component of pain-management programmes for children with chronic neuropathic pain such as CRPS-I is based primarily on Level IV scientific evidence—that is, case studies and expert consensus opinion derived from clinical practice in treating children's functional limitations and altered sensitivity—as

well as on our understanding of the aetiology of CRPS and on data extrapolated from adult studies.

At present there are few well-designed studies with the primary objective of evaluating the effectiveness of physiotherapy. Yet converging lines of evidence from the available cohort follow-up studies, retrospective chart reviews, and one RCT document that interdisciplinary programmes such as the “3 Ps” approach described here are effective for many children with CRPS. Common themes emerging from these studies are

1. that physiotherapy is typically the primary component of a child-centred treatment programme that also includes analgesics, adjuvant analgesics, and psychological therapy;
2. that most children improve with treatment, as assessed by the varied measures of pain, physical signs, and function;
3. that the differential efficacy of physiotherapy, medication, and psychological components has not been determined;
4. that some children do not respond despite multiple treatment efforts; and
5. that many children with CRPS experience high recurrence rates.

For all the interventions to treat children's chronic pain, we urgently need data on child-centred treatment efficacy, identifying when interventions are selected for the individual child with pain and based on an assessment of the specific factors contributing to the child's pain and disability (such as those illustrated in Figure 2). We also need longitudinal studies to identify key risk factors that influence a child's vulnerability to continuing pain or recurrences. However, we could learn much by adopting an evidence-based or evidence-accruing approach (the term we use in our programme) throughout our regular clinical practice. For example, pain clinics for children could adopt standardized assessment approaches—not only for pain, as has been advocated in the PedIMPACT recommendations,⁷³ but also for all of the “3 Ps” that are critical in caring for children with chronic pain.

Finally, practical assessment scales that document the quantity of physiotherapy and the primary physical modalities used with each child, similar to those used in our case study to document Lucy's status, should be developed. Consistent documentation would enable us to better identify the critical components of therapy that contribute to children's improved health status. Such improved evidence-accruing clinical practice will complement data obtained in future experimental studies to determine the effectiveness of physiotherapy. We must develop innovative study designs to obtain stronger evidence about the essential role of physiotherapy in treating children with chronic pain.

KEY MESSAGES

What Is Already Known on This Topic

Chronic pain in children requires a biopsychosocial treatment approach involving an inter-professional management team employing multimodal treatment techniques. Physiotherapists are uniquely qualified to provide inter-professional expertise in the assessment and management of children with chronic pain, thanks to their substantial knowledge of chronic pain mechanisms, which is now a focus in several undergraduate training programmes.

What This Study Adds

It is apparent that data on the efficacy of child-centred treatment interventions for children with chronic pain are critically needed. Specifically, physiotherapy assessment and management of children with chronic pain requires the consistent use of practical evaluation measures, which can be adopted in an evidence-accurring approach within the clinical environment.

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