BRAIN INJURY professional

vol. 18 issue 2

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Beth S. Slomine, PhD, ABPP

from the editor in chief

It is a pleasure to serve as Editor-in-Chief for this issue of *Brain Injury Professional* that provides an overview of Constraint Induced Movement Therapy (CIMT), an intensive evidence-based interventions for individuals throughout the lifespan with acquired brain injury (ABI) and associated hemiparesis. For the last two decades, there has been a growing body of literature exploring this evidence-based intervention which was originally developed for adults with upper extremity weakness following stroke.

The guest editors for this issue, Dr. Joan Carney and Ms. Teressa Reidy, are experts in pediatric rehabilitation care and the topic of CIMT for children with ABI. Dr. Carney, who is an educator by training, currently directs several interdisciplinary rehabilitation and early intervention programs at Kennedy Krieger Institute. She is also the site PI for the I-ACQUIRE P-CIMT trial, a large multicenter dosage trial of CIMT in young children which is described more fully within this issue. Reidy is an occupational therapist in the Specialized Transition Program at Kennedy Krieger Institute. Reidy has expertise in delivering CIMT as well as other evidence-based rehabilitation interventions for children with ABI. She is also actively engaged in research involving CIMT. Together this interdisciplinary duo pulled together an informative issue that highlights the latest research in CIMT throughout the lifespan.

The feature article, entitled "How Constraint-Induced Movement Therapy Changed Rehabilitation and the Science that Guided It," written by renown experts in the field of rehabilitation, Drs. DeLuca, Ramey, and Wolf, summarizes the existing literature base on the efficacy of CIMT and highlights the key components of the intervention. The issue includes many other excellent articles, each packed with relevant information for brain injury professionals from a range of disciplines who work with individuals with ABI throughout the lifespan and from around the world. A few highlights include the benefits of implementing CIMT via telehealth by Guathier, Proffitt, Borstad, and Kelly and the implementation of pediatric CIMT in international settings by Coker-Bolt and DeLuca. The patient and parent interviews, brought to us by Trucks and Wallace, provide a real-world view of the impact of hemiparesis following ABI and the benefit of CIMT for patients and families.

Finally, mark your calendars for these upcoming events. The International Brain Injury Association's Disorders of Consciousness Special Interest Group (IBIA DoC-SIG) is pleased to announce that the IBIA Inaugural Conference on Disorders of Consciousness will take place virtually in December 9 - 10, 2021. This Conference seeks to promote the rapid dissemination of contemporary scientific studies and expert perspectives relating to the management of patients in experiencing coma, vegetative state/unresponsive wakefulness syndrome, minimally conscious state and other clinical conditions collectively referred to as Disorders of Consciousness (DoC). Additionally, two in-person conference events will be held in 2022. The North American Brain Injury Society (NABIS) will hold the 34th annual Conference on Medical and Legal Issues in Brain Injury and the International Paediatric Brain Injury Society (IPBIS) will hold the Fourth International Conference on Pediatric Acquired Brain Injury. Both events will take place September 21 - 24, 2022 in New York City. For more information, go to https://www.internationalbrain.org/meetings-and-events/ibia-webinar-series

Editor Bio

Beth S. Slomine, PhD, ABPP, is co-director of the Center for Brain Injury Recovery and director of neuropsychology training and neuropsychological rehabilitation services at Kennedy Krieger Institute. She is an Associate Professor of Psychiatry & Behavioral Sciences and Physical Medicine & Rehabilitation at Johns Hopkins University School of Medicine. She is a licensed psychologist, board certified clinical neuropsychologist, and board certified subspecialist in pediatric neuropsychology. Research interests include developing neurobehavioral assessment tools and understanding factors influencing outcome following pediatric neurological injury. Dr. Slomine has authored >70 peer-reviewed manuscripts, numerous book chapters, and co-edited a textbook entitled Cognitive Rehabilitation for Pediatric Neurological Conditions.

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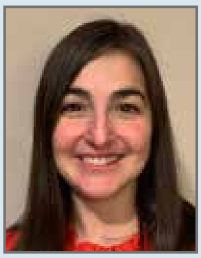
from the guest editors

Editor Bios

Joan Carney, EdD, is the Assistant Vice President of Clinical Programs at the Kennedy Krieger Institute and an Assistant Professor, Physical Medicine and Rehabilitation at the Johns Hopkins University School of Medicine. Dr. Carney directs several interdisciplinary rehabilitation and early intervention programs as well as a statewide training grant. She is a board member of the Brain Injury Association of Maryland and serves on Maryland's Governor's Advisory Board for Traumatic Brain Injury. She has experience as a clinical leader in innovative program design and implementation. Her programs focus on community integration with specific expertise in brain injury, cerebral palsy, and chronic pain. She has engaged in scholarly work with these populations and has been part of multiple program evaluation and efficacy activities surrounding pediatric constraint induced movement therapy. Dr. Carney is currently site PI for a large multi-site investigation of CIMT with young children.



Teressa Garcia Reidy, MS, OTR/L is a Senior Occupational Therapist in the Specialized Transition Program at Kennedy Krieger Institute in Baltimore, Maryland. She has made significant clinical, research and training contributions to the field of pediatric occupational therapy. As a clinician-researcher, her areas of expertise are in constraint induced movement therapy, traumatic brain injury and congenital and acquired neuromotor impairments. She has published on the topics of evidence-based practice, CIMT, intensive therapy models and clinical reasoning in occupational therapy. Teressa is currently a study team member on two approved research projects focused on clinical and patient-centered outcomes of intensive therapy protocols. She assisted with the upper extremity motor battery design and is a study team member on a drug trial for children with Sturge-Weber Syndrome.

A patient who was told she would never use her hand in a meaningful way opened a zip top bag with two hands and ate a snack by herself. How would that make you feel as her therapist? As her caregiver? Constraint Induced movement therapy has given this family the gift of independence and the patient the gift of self-efficacy.

We thank the editors in chief for inviting us to share our experiences and insights from working in this area of clinical practice for more than 15 years. We were pleased to invite many of our colleagues who have contributed to the evolution of this treatment for patients with strokes, traumatic brain injury and cerebral palsy.

The primary features of Constraint Induced Movement Therapy (CIMT) involve high intensity focused use of the affected upper extremity with progressively more challenging tasks and some type of constraint to restrict use of the dominant extremity. With CIMT many families and patients are for the first time finding a treatment that focuses not on compensatory techniques to cope with disability but true remediation of upper extremity deficits. As rehabilitation professionals treating patients with a variety of etiology for their upper extremity motor impairments, constraint provides an option to maximize the movement available. It also uncovers strategies to use two hands in a functional, common sense way that can be life altering for those with hemiplegia.

Our CIMT program at Kennedy Krieger Institute has been in existence since 2004 as a part of our intensive day neuro-rehabilitation program. It has evolved with the ever-increasing body of literature on this topic. Trialing this intervention, that had case study level evidence at the time, was innovative and experimental. What started as a few test patients evolved and blossomed to a continual stream of children receiving intensive, evidence-based intervention with a focus on gaining function and bimanual coordination. Our team committed to staying current with the literature and adapted the newly established clinical protocol as new evidence became available. Rapidly, that promising case level evidence materialized into RCTs and multi-site RCTS. Something that, in the rehabilitation world, was exciting and rare. Pioneers Deluca, Ramey and Wolf describe this evolution in detail in the feature article. Blending the art and science of rehabilitation with protocol-based intervention was a welcome challenge. For one of the first times in many of our therapists' careers there was a shift to a manualized, protocol driven treatment for hemiplegia.

CIMT had its beginnings in the treatment of adult stroke but, as we are reminded in the article describing stroke across the lifespan, children are at risk too. In fact, perinatal stroke is one of the most common causes of cerebral palsy. Readers of this issue will find examples of the use of CIMT with both adult and pediatric populations who have experienced stroke or other neurological insult or injuries resulting in hemiplegia.

Whether an adult or a pediatric client, Naber and Andrejow offer considerations that can guide decision-making when planning to incorporate CIMT in a plan of care. Beyond the decisions regarding dosage, setting, and choice of constraint, patient goals and priorities figure prominently. Readers will likely find the decision tree offered a useful tool. For the youngest patients, Tanner and colleagues describe their clinical coaching model and report creating and delivering a protocol requires constant reflection, program evaluation and improvement plans to ensure best practice.

The advent of more widespread use of telehealth has had appropriate application in CIMT. As Gauthier and colleagues inform, motor-practice self-managed at home with gaming can be both more engaging and allow the therapist to focus on behavioral intervention to reinforce habitual use of the paretic upper extremity. Trapp reviews other applicable technologies such as considering robotic-assisted CIMT. Although, as new technologies they are being welcomed into clinics providing intensive rehabilitation models, interventions with robotic assistance present concerns both in availability and evidence to support the efficacy of their use.
CIMT has a fairly long history in the United States and research is continuing to refine the evidence to guide its use. Still, many clinicians have not been formally trained in its use and some remain hesitant. Coker-Bolt and DeLuca present a framework of how to build capacity in low and middle-resource countries such as Vietnam and Ethiopia. Their work demonstrated a model to improve the quality of rehabilitation to children with disabilities and their families across international boundaries.

What do patients and their caregivers think about their experience with CIMT? Interviews with participants give the readers of this issue a unique perspective of the benefits and challenges that come along with being the recipient of CIMT. The interviewees give their unabridged advice. These interviews give great insight to any clinician considering CIMT in their practice.

We hope you find this issue both informative about the evolution of this evidence-based intervention and that it provides practical direction for your clinical practice.

How Constraint-Induced Movement Therapy Changed Rehabilitation and the Science that Guided It

A synopsis of the history and contributions of CIMT

Stephanie C. DeLuca, PhD • **Sharon Landesman Ramey**, PhD
Steven L. Wolf, PT, PhD, FAPTA

Constraint-Induced Movement Therapy (CIMT) began more than two decades ago as a novel therapeutic approach that has helped individuals with hemiparesis achieve improvement in movement, skills, and function. “CIMT protocols” yield >90,000 in Google Scholar (on 1-14-21). This new body of knowledge spans the translational spectrum of biomedical science. Recent and ongoing CIMT clinical trials are poised to transform medical rehabilitation: e.g., I-ACQUIRE (NCT03910075) is the first-ever Phase 3 dosage trial focused on CIMT for infants with perinatal stroke; TRANSPORT 2 (NCT03826030) is a Phase 2 trial testing neuromodulation with CIMT post-stroke; and a tele-rehabilitation trial is a Phase 3 trial demonstrating non-inferiority of a tele-rehab version of CIMT compared to traditional in-person delivery[1]. Core distinguishing characteristics of CIMT include: 1) constraint of the uninvolved or less-impaired upper extremity (UE); 2) high-density dosage of active therapy; and 3) therapy involving principles of operant conditioning and motor learning, including reinforcement with explicit feedback to induce and then shape new UE behaviors through successive approximations and repetitive and varied task practice[2-5]. This paper advances the premise that CIMT scientific inquiry has paved the way for a broader medical rehabilitation agenda by exemplifying use of basic science findings, implementing rigorous RCT methods, and proposing novel concepts about future directions for the field. The principles informing CIMT and incorporated into CIMT clinical trials increasingly are being woven into rehabilitation science and clinical practice. These include hypotheses about treatment-induced neuroplasticity; the efficacy of other forms of high-density ‘intensive’ therapies, such as bimanual therapy[6]; the need for well-defined and thus replicable rehabilitation protocols that can be monitored for treatment fidelity; and the exploration of potential biomarkers, such as genes regulating dopamine that may mediate differential patient outcomes[7,8]. CIMT research in both adults and children has encountered well-recognized issues concerning natural heterogeneity in clinical populations and major limitations in identifying primary and secondary treatment outcomes that can adequately capture benefits meaningful to patients and clinicians. Many CIMT trials now serve as models of team science with scientists, clinicians, caregivers, and patients/advocates working collaboratively towards these goals.[9-12]

A next-step in CIMT moves the field toward a vision of precision-rehabilitation: the awareness that individuals vary both biologically and behaviorally in ways that may impact treatment decision-making, response, and outcomes[13,14]. Results from systematic-empirical inquiry focused on individual differences may lead to far better matching of which individuals should receive what types and dosages of CIMT, alone or in combination with other interventions (e.g., neuromodulation, bimanual therapy, wearable sensors), and at what timepoints in their lives. Framing the next era of CIMT clinical trials and meta-analyses of existing datasets in terms of precision-rehabilitation also offers an unprecedented opportunity for improving long-term quality of life for individuals whose neuromotor impairments – when not adequately treated - create major limits for their health (including multiple secondary disabilities), employment, and full community participation. Precision-rehabilitation as a framework benefits immeasurably by engaging key stakeholders -- scientists, patients, clinicians, and health care systems and policy experts -- in the design, conduct, analysis, and interpretation of results from rigorous clinical trials.

Early studies of pediatric CIMT (P-CIMT) reported what were considered unanticipated benefits or “spillover effects” that included changes in multiple domains not specifically designated as CIMT treatment goals, including improved speech, posture, ambulation, social interactions, reduction of behavior problems, and willingness to engage in challenging learning activities[15-17]. These early anecdotal and qualitative observations contributed to a shift in rehabilitation science that now explicitly recognizes the need to measure changes that go beyond direct indicators of neuromotor impairment. These concepts include considerations related to overall health, perceived well-being, individual agency, and engagement in community activities and hypothesize these are important targets to incorporate when designing, planning, and implementing an intervention. Behaviorally focused and high-density interventions, such as CIMT, now are merging with biomedical engineering approaches (e.g., neuromodulation, biofeedback wearable sensing devices), genomics (e.g., genetic markers that predict responsiveness to interventions), and kinematic behavioral measurement to identify bio-behavioral markers to consider in tailoring rehabilitation to maximize functional health and well-being across the life-span[18-20]. Thus, in many ways scientific investigation surrounding CIMT has paved the way for adopting precision-rehabilitation as a guiding conceptual framework.[14]

CIMT in the context of translational science

One way in which CIMT has undergirded precision-rehabilitation is through its history, starting with animal model experiments. The experiments were designed to identify how learning impacts motor (efferent) pathways when sensory (afferent) pathways were experimentally disconnected (deafferented)[21]. After unilateral deafferentation of a forelimb at the dorsal root entry of the spinal cord, at various times in development, post-deafferentation procedures documented differential forelimb use. Somewhat surprisingly, animals could be directed (or "forced") via extended constraint of the intact forelimb coupled with various training methods to use the deafferented forelimb in daily life, despite lack of sensory input.[21 22] This contradicted prior findings of permanent paralysis in a deafferented forelimb[22] and led to two novel insights for the neurorehabilitation community: 1) expression of a disability might not match the actual nervous system anatomical damage; and 2) recovery from CNS damage might be more amenable to behavioral interventions than previously thought[21]. This basic science work was foundational for Steve Wolf's first human stroke case studies[23] that "forced use" of the hemiparetic arm-and-hand by constraining the functioning arm-and-hand. Then Nudo[24] et.al conducted seminal research using a non-human primate stroke model that applied constraint with behavioral training, resulting in discovery of a dose-dependent cortical expansion associated with the intervention[24]. Collectively, these findings combined to create what ultimately became CIMT.

Next in the CIMT translational process was the design and conduct of "The Extremity Constraint Induced Therapy Evaluation (EXCITE) Trial," the first NIH-funded multisite Phase 3 clinical trial involving 7 sites and >200 patients with chronic stroke[12 25]. EXCITE directly compared outcomes from a well-delineated CIMT protocol to usual and customary rehabilitative care (UCC)[12]. EXCITE demonstrated that CIMT produced significant and clinically relevant benefits compared to UCC, with benefits extending at least 24 months post-intervention, suggesting potential permanency of benefits. An important feature of EXCITE was that participants were 3-9 months post-stroke, when they traditionally exceeded eligibility for active treatment, based on the assumption (untested) that further progress was unlikely to occur. Half were randomly assigned to receive CIMT immediately and half did not, although they could receive other therapies for a year. The UCC group then received the 2-week intensive CIMT a year later. Both the initial Immediate CIMT group and the delayed CIMT group showed significant gains on the WOLF Motor Function Test, while the UCC group did not. Additional measures included self-report about amount and quality of upper extremity use (Motor Activity Log) and quality of life (Stroke Impact Scale) demonstrating time-appropriate significant improvements. Then, the same EXCITE CIMT protocol and participant inclusion criteria was tested on another sample, producing comparable findings[12 25] with new evidence from transcranial magnetic stimulation revealing for the first time in humans that CIMT induced cortical expansion of the muscle groups contributing to wrist extension immediately post-treatment and 4-months later[26]. Once again functional improvements were maintained[26 27].

Several interdisciplinary teams of developmental psychologists, therapists, pediatric neurologists, and neuroscientists began to adapt the adult CIMT approach for children[17 28 29]. For example, DeLuca, et al. developed a novel form of CIMT for a 15-month old with asymmetric quadriparesis that was implemented at two time periods [17]. Their novel adaptation involved a rigid full-arm constraint worn full-time, unlike the adult constraint worn during most waking hours only. The cast was introduced because very young children, unlike adult stroke patients, were not restoring prior skills but acquiring skills for the first time. The cast effectively and almost immediately re-directed the child's attention to the hemiparetic UE. The child rapidly gained reaching abilities, a whole-hand palmer grasp, and sitting balance for the first time in her life during the first P-CIMT session. Then during the second P-CIMT episode at 21 months old, the child added many new fine-motor abilities and learned to crawl. Taub, et al. then completed the first pediatric RCT which demonstrated P-CIMT produced significantly greater gains in new UE skills, as well as frequency and quality of use, in 2- to 8-yr old children with hemiparesis[15]. Further, the immediate large gains were maintained or increased over the next 6 months. This tested form of P-CIMT involved 6 hours of daily intervention with a full-time cast over 20 treatment days (120 hours) compared to UCC which averaged 2.2 hours per week. When UCC controls were crossed over to receive P-CIMT, similar results obtained[15]. Charles and Gordon, demonstrated similar positive benefits for P-CIMT via a set of case-reports in 2001[29], and later went on to demonstrate that a high-intensity bimanual approach to therapy, informed by the same foundational learning principles first applied in CIMT, also was highly efficacious in helping children with hemiparesis gain increased function and skill with their hemiparetic UE6.

Variations and adaptations of CIMT

Clinical and research interest in CIMT continues to grow. Two decades later, many variations in pediatric and adult CIMT have been described and evaluated, with variations related to the type and duration of constraint, therapy dosage, guiding principles for the choice and progression of tasks and activities, and who delivers the treatment. Unfortunately, these treatment protocols often lack specific written descriptions; seldom is intervention fidelity monitored and reported. As a result, opportunities to learn about the relative merits of these protocol variations are precluded. Reiss, et.al. were among the first to emphasize the importance of better understanding these "modified CIMT" approaches[4]. They recognized both "strengths and weaknesses" of protocol variations compared to what they termed the "signature" highly intensive CIMT approach that employed operant conditioning techniques with feedback to patients, as originally tested in the adult RCTs. Similarly, Ramey, et.al. proposed 5 necessary or essential components for P-CIMT models that serve to differentiate the forms labelled "signature," "modified," and "alternative" P-CIMT[5]. Operationalizing differences across CIMT approaches for adults and children drew attention to the criticality of detailed documentation of rehabilitation interventions. CIMT, like many prior rehabilitation treatments, was now becoming so varied that any meta-analysis or systematic comparative efficacy analysis was problematic. Additionally, differences in the targeted clinical populations regarding etiologies, severity of hemiparesis, co-morbidities, ages, and lack of a single best or widely used outcome measure further challenged translating results of published research into evidence-based guidelines. Consequently, in practice, clinicians and patients/parents often choose their own versions of a “CIMT approach,” with little to no evidence to substantiate that these creative versions offer sufficient dosage, constraint, and/or adherence to enacting principles of operant conditioning and motor learning to yield meaningful or enduring benefits. In fact, most published CIMT studies are relatively small-scale Phase 2 clinical trials or clinical case series. TABLE 1 defines signature CIMT’s core elements.

Finally, a future remaining step for CIMT inquiry is to conduct Implementation Science trials to determine effective strategies that will promote widespread adoption of treatment protocols proven efficacious - including demonstrating high fidelity in a variety of clinical settings and across heterogeneous clinical populations[14 30-32]. As results emerge from CIMT research and rehabilitation trials across the lifespan, patients and clinicians will benefit immensely from the resulting knowledge.

CIMT challenged clinical assumptions about the course of recovery Since its inception, CIMT outcomes document far greater potential for improvement during the chronic period after CNS injury, as well as a likely threshold for density dosage (high amounts of therapy in relatively short periods of time) to realize clinically meaningful and enduring gains. These discoveries overturn long held but incorrect assumptions that after early periods of recovery little or no progress could occur. Additionally, other widely-used rehabilitation treatments failed to demonstrate efficacy[33 34]. The rehabilitation field rarely considered that implicit attitudes (or biases) of low expectations for recovery might have influenced participation in rehabilitation and, in turn, negatively impacted treatment outcomes. Typically, most patients received a mix of different daily therapy treatments while hospitalized, followed by a fixed duration of “rehabilitation” in a rehabilitation center (or early intervention program for young children), and then either ended rehabilitation or reduced to a low dose of one or two hours/week. Many patients were exposed to multiple therapists who focused on different aspects of recovery – including occupational, physical, speech-language, and psychological therapy along with social work supports – but patients/parents often received discrepant or conflicting advice. Logistical difficulties and lack of coordination across providers and complexities of insurance coverage likely contributed to sub-optimal benefits. In contrast, the highly successful approach CIMT offered was a commitment to a very high, concentrated dosage of therapy, informed by research evidence and principles of learning about massed practice that promotes functional movement and CNS re-organization. Further, these highly dense therapy periods most often are guided by a single provider following a specified protocol with clear expectations for participation (with known start and stop points) for patients and their care-partners.

Table 1: Signature Forms of Constraint-Induced Movement Therapy

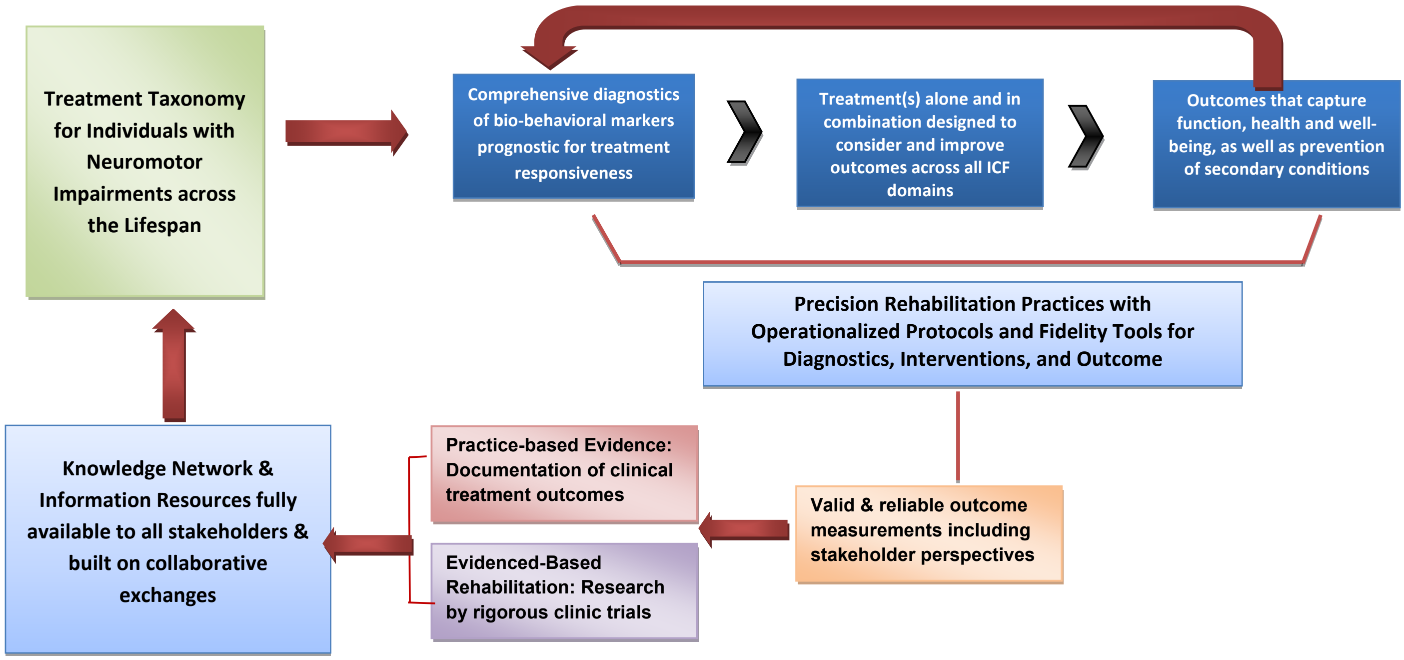
Five Essential Components of CIMT	*Signature or Traditional CIMT for Adults	*Signature or Pediatric CIMT
1. Constraint of the less or unimpaired upper extremity	Constraint of the less or unimpaired upper extremity for target of 90% of waking hours and during active treatment	Constraint of the less or unimpaired upper extremity for majority of waking hours and during active treatment
2. High dosage (likely minimum threshold)	High dosage of therapy in a concentrated period of time involving active treatment for 6 hrs/day for 5 days/wk for 10 days or more	High dosage of therapy in a concentrated period of time involving active treatment for a minimum of 3 hrs/day for 5 days/wk for multiple weeks
3. Use of shaping techniques and repetitive practice with task variation	Use of shaping techniques to review, extend, practice, and refine skills that use formal operant learning techniques with immediate feedback and reinforcement in all treatment sessions	Use of shaping techniques to review, extend, practice, and refine skills that use formal operant learning techniques with immediate feedback and reinforcement in all treatment sessions
4. Learning functional skills in natural and diverse settings	Encouraging functional skills in natural and diverse settings	Delivering treatment in natural settings (e.g. home, childcare, school) rather than a traditional clinical setting
5. Transition (post-therapy) planning for maintenance of gains	Post-therapy planning to promote functional bilateral and unilateral upper extremity development and continued practice of new skills with more-impaired upper extremity	Post-therapy planning to promote functional bilateral and unilateral upper extremity development and continued practice of new skills with more-impaired upper extremity
Eligibility movement criteria of impaired upper extremity	**10^0 of Finger Extension** **20^0 of Wrist Extension**	**None Pre-specified, although child must have ability to follow simple instructions and imitate**

*Table provides signature CIMT references indicating version first studied in RCTs with children and adults and components were identified and adapted from:

Ramey, S.L. & DeLuca, S.C. (2013). Pediatric constraint-induced movement therapy: History and definition. In S.L. Ramey, P. Coker-Bolt, & S.C. DeLuca (Eds.), *Handbook of pediatric constraint-induced movement therapy (CIMT): A guide for occupational therapy and health care clinicians, researchers, and educators.* (pp. 19-39). Bethesda, MD: AOTA.

Reiss, A.P., Wolf, S.L., Hammel, E.A., Erin L. McLeod, E.L., & Williams, E.A. (2012). Constraint-Induced Movement Therapy (CIMT): Current perspectives and future directions. *Stroke Research and Treatment*, *Article ID 159391*, 1-8. doi:10.1155/2012/159391

FIGURE 1: Precision Practice: A Translational Systems Framework Integrating Current Research, Rehabilitation Practices, and Supported Networks to Promote Knowledge and Information Resources for Practitioners (adapted from S. Ramey, Coker-Bolt & DeLuca, 2013; National Research Council, 2011).



Towards an Integrated Precision-Rehabilitation Framework

FIGURE 1 provides a view of how an integrative collaboration among investigators, across the translational science continuum, might blend with knowledge and insights from clinicians, patients, their families (advocates), and health care system administrators. Leadership for realizing this framework can be shared and include continuous updating about rehabilitation topics regarding the targeted patient population (e.g., CNS insult, age group) and the types of interventions being studied. Ideally, with shared lifespan goals of improving health, participation, and quality of life, treatments in the community need to be studied in terms of immediate, direct, and objective benefits plus multi-domain health and functional outcomes. This approach leads to emphasis on the value of timely and transparent sharing of public use clinical trials datasets (a requirement in most NIH trials), and the potential value of conducting clinical trials that specifically test combinations of therapies – reflecting more accurately what both adults and children receive in their communities – along with testing sequential or repeated courses of treatment. Further, remarkably little research has considered documenting the natural events or patient-initiated types of activities that may enhance (or limit) benefits related to the tested interventions. Finally, by including promising biomarkers that theoretically could differentiate which individuals benefit more (or less) from specific forms of CIMT and other intensive therapies, the precision-rehabilitation framework could yield an impact far beyond the already known results of independent RCTs.

EXCITE was perhaps among the first study to document that individualization could occur via a multi-component behavioral intervention, because patients naturally vary in their baseline performance. Similarly, other pediatric RCTs have been designed as comparative efficacy clinical trials, manipulating dose and type of constraint (e.g., CHAMP11); or contrasting unilateral and bilateral approaches for infants of comparable dosage (Baby CHAMP) or for older children, or manipulating dose alone (I-ACQUIRE).

These and other studies were explicitly conceptualized to resolve some of the pressing clinical choices in the P-CIMT protocol to use with particular patient populations. Increasingly, many of these trials now include measuring outcomes in multiple domains and collect biomarker data to explore genetic and other biological differences (e.g., dopamine regulation, typical cortisol rise, new methods of coding CNS infarcts). As the precision-rehabilitation framework is more widely adopted, the field likely will benefit and extend into Implementation Science[35] to understand how to ensure high fidelity and equitable implementation of efficacious rehabilitation in real-world settings, recognizing individual differences and pragmatic factors.

Integration of Biotechnology Advances in Precision Rehabilitation

Rehabilitation professionals have a daunting task in this expanding era of precision-rehabilitation which will encourage patients to be empowered and true partners in their own rehabilitation. Computer-assisted technologies in mobility, robotic use of limbs, and communication assistive devices all have made impressive and potentially transformative advances for individuals with neuromotor impairments. Rehabilitation science is also facing the issue of integrating new technologies: for example, the ability to alter gene expression and functioning with technologies such as CRISPR and application of direct neuromodulation in combination with behavioral interventions. Often these exciting advances are celebrated long before they have been rigorously tested for safety, feasibility, benefits, and potential long-term iatrogenic effects. For example, while computer-based compensatory technologies aid individuals in negotiating the environment, there is a risk that some treatment plans may inadvertently neglect a concomitant need to have patients maximize their neuromuscular competence and realize improved health, achieving a balance between use of technology and self-initiated movement. Finding this right balance of technology, environmental accommodation(s), and individual functional competencies is never easy.

Ideally, future clinical trials will systematically test multiple interventions and innovative uses of technology, as independent treatment processes and combined when appropriate. This step is a necessary precursor to allow science to guide the implementation of varied approaches.

Conclusion and Future Directions

Choices about rehabilitation treatments should involve joint decision-making among patients and clinicians, guided by accessible scientific findings. Historically, rehabilitation professionals have had scant information to share with patients about efficacy of most forms of available treatments. Continued design and conduct of Phase 2 and Phase 3 neurorehabilitation trials – with better measurement of patient characteristics, environmental features, treatment fidelity, and a more "total person" perspective of meaningful outcomes can benefit from discoveries over the past two decades of scientific inquiry into CIMT. The Eunice Kennedy Shriver National Institute of Child Health and Human Development has put forward new Rehabilitation Research themes which include: 1) rehabilitation across the lifespan; 2) community and family; 3) technology use and development; 4) research design and methodology; 5) translational science; and 6) building research capacity and infrastructure36. These themes represent an ambitious and achievable vision with the potential to transform the practice of evidence-based rehabilitation and the overall health, functioning, and quality of life for individuals whose neuromotor control and subsequent development have been altered by CNS damage or disease.

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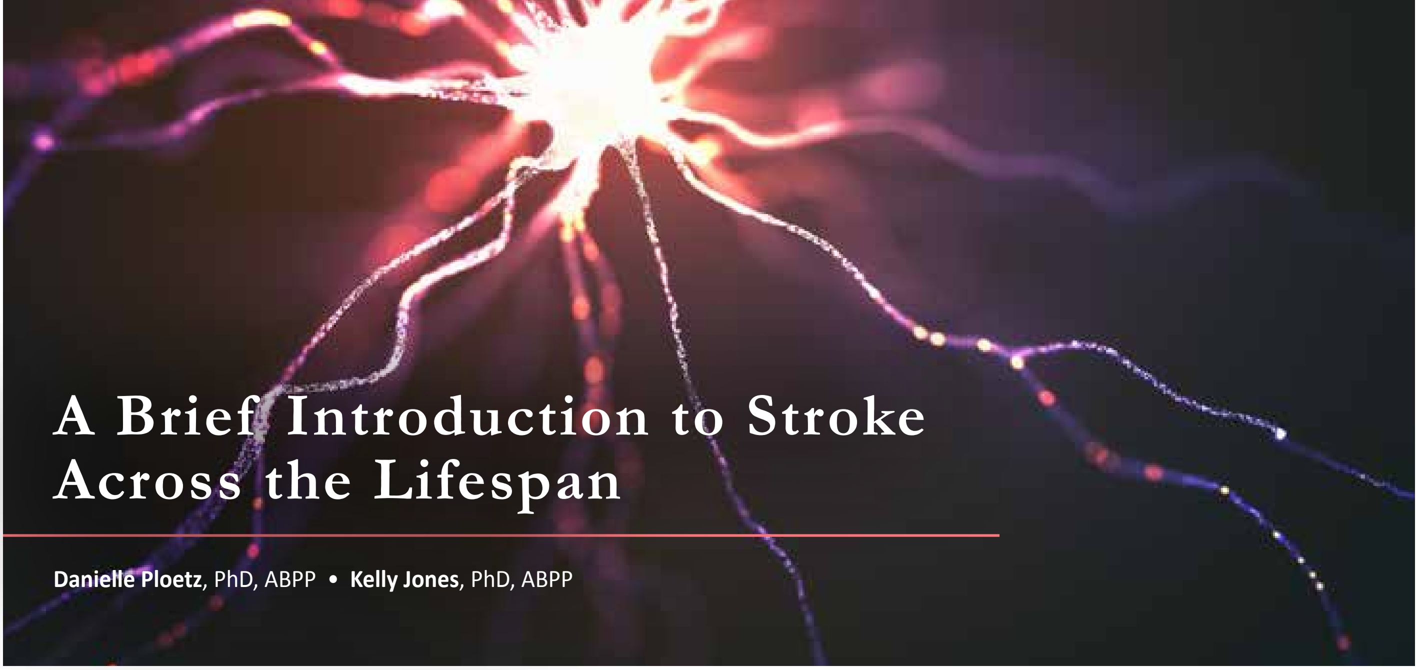

A Brief Introduction to Stroke Across the Lifespan

Danielle Ploetz, PhD, ABPP • **Kelly Jones**, PhD, ABPP

Stroke occurs when oxygen supply to the brain is suddenly interrupted or reduced. Without sufficient oxygen, cells in the brain begin to die, resulting in reduced functioning of that part of the brain. Stroke can be classified as ischemic (insufficient blood flow to brain) or hemorrhagic (rupture of blood vessels).

Stroke is the second leading cause of death worldwide and affects individuals across the lifespan. In the United States, 795,000 people have a stroke per year with 75% of those occurring in individuals over the age of 65. Ischemic and hemorrhagic stroke are equally common in children but ischemic stroke is far more common in adults (about 88%).[1] The incidence of perinatal stroke ranges from 1 in 1,100 to 3500 full-term births. Perinatal stroke occurs between 20 weeks gestation through the first 28 days of life and is one of the most common causes of cerebral palsy.[2]

Etiology differs for children and adults. For ischemic stroke, risk factors for children include cardiac disease, infection, and brain artery disease (e.g., sickle cell disease) and risk factors for adults include age, hypertension, atrial fibrillation, drug use, and obesity.[2] Hemorrhagic stroke most often results from aneurysm or hypertension in adults while childhood hemorrhagic stroke most often results from trauma (e.g., TBI), intracranial abnormalities (e.g., AVM rupture), and brain tumors.[2] Psychosocial factors, including low socioeconomic status, non-white race, and female gender are also associated with increased risk of stroke.[1]

Improving lifestyle factors such as nutrition, exercise, sleep, and stress are central in preventing stroke in adulthood. Identifying and managing risk factors such as high blood pressure, high cholesterol, and diabetes are also important. For children, routine medical and neurodevelopmental follow-up for conditions with increased risk of stroke (e.g., sickle cell disease, congenital heart disease) are essential. Early identification of stroke is crucial in preventing long-term disability and death. [3]

Depending on the location in the brain, stroke can cause changes in motor (e.g., hemiplegia), speech (e.g., aphasia), thinking (e.g., attention, memory, hemispatial neglect), and/or emotional functioning. Rehabilitation treatment plans are designed based on the individual's unique combination of deficits. It is important to receive interdisciplinary care including neurology, rehabilitation medicine, neuropsychology, and rehabilitation therapies to optimize recovery of function.

Rehabilitation following stroke may include medication management, physical activities, communication-focused therapy, cognitive rehabilitation, and emotional support (e.g., psychotherapy). Constraint-induced movement therapy (CIMT) is also frequently used for children and adults to address resulting hemiplegia. More recently, advances in technology has expanded therapeutic options. Initiatives to increase awareness of stroke have led to earlier identification and treatment, resulting in reduced mortality and improved outcomes.

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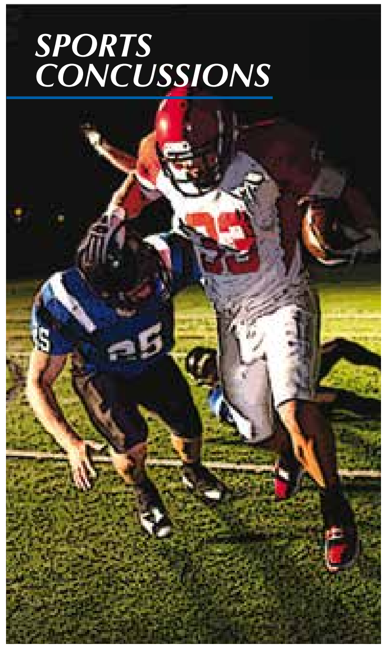


Functional and Clinical Considerations of Intensive Upper Extremity Therapy Models

Erin Naber, PT, DPT • **Nicole Whiston Andrejow**, MS, OTR/L

Introduction

Intensive therapy approaches seek to capitalize on the concepts of motor learning to assist patients in achieving their functional goals through massed practice and shaping of new skills. As the body of evidence in support of intensive upper extremity (UE) therapy models continues to expand, clinicians may seek the best way to incorporate these interventions into their practice. A number of clinical and functional considerations can guide decision-making when designing a plan of care to best meet the need of each patient. Clinical considerations include the timing of the intervention, dosage and setting of intervention, as well as the use of casting of the less affected UE. Each patient's functional goals, priorities and personal factors will guide the plan of care.

Considerations for Modifications of Traditional CIMT

By definition, intensive models of care involve an increase in direct therapy intervention time per day for a defined time period. When scheduling an intensive bout of UE therapy, clinicians will need to determine the most appropriate therapy dosage to best meet the individual needs of each patient. For many therapists, choices about dosage are limited clinically by therapy setting, caseload or insurance. In addition, patient and family factors may limit their ability to attend multiple hours per day of therapy[1]. Participating in work or school may limit the hours in a day that a patient is available to attend therapy.

In situations where increasing frequency of sessions is not feasible, therapists may consider use of other providers or caregivers assisting with practice of functional skills through a specific therapeutic home activity program or telehealth delivery[2]. Along with telehealth models, technology can also be used to increase access to therapy sessions with the use of therapeutic gaming technology or robotic devices[3]. Devices such as the HandTutor™ by Meditutor and Music Glove™ facilitate highly repetitive practice through games with customizable settings to target specific movements, grade difficulty, or length of practice.

Optimizing the Timing of Intervention

Given the high number of direct treatment hours involved in intensive intervention models, they should be timed to optimize functional gains while minimizing disruption to the patient's typical routines and roles. Scheduling an intensive bout of care around a medical intervention, such as treatment for tone management, may allow for increased potential functional gains[4]. For a child, intensive therapy may be scheduled to coincide with emerging skills to capitalize on natural development. For example, planning an intensive program when a child demonstrates interest in dressing allows the therapist the advantage of working intensively on a goal that is highly motivating to the child[5]. In addition to timing intensive programs to optimize functional gains, clinicians should also consider timing that aligns best with the patient and their caregivers' schedule such as a school break for a child, or during the time of year a patient or caregiver can more easily take off work. Therapy sessions may need to be scheduled in the early morning or in the evening to accommodate the needs of each patient or caregiver. Patient and caregiver preference in determining timing for an intensive bout of therapy is essential for a patient-centered plan of care.

Intensive Therapy Research Outcomes

Research has consistently reported gains in patients' UE function following both constraint induced movement therapy (CIMT) and intensive bimanual therapy (IBT) programs when compared to standard care[6,7,8]. Traditionally, CIMT has involved a combination of casting the less affected UE for 24 hours a day while completing intensive therapy for 3-6 hours with repetitive practice of new motor skills with the more affected UE to shape new motor patterns[9]. As this treatment approach has developed, it has been modified in type of constraint used, the duration of constraint, and therapy dosage[7]. For example, a modified CIMT protocol may include 3 hours of intensive therapy daily with the constraint worn only in therapy sessions, or it may include 1 hour of intensive therapy daily with a soft mitt instead of a long arm cast on the patient's more affected UE.

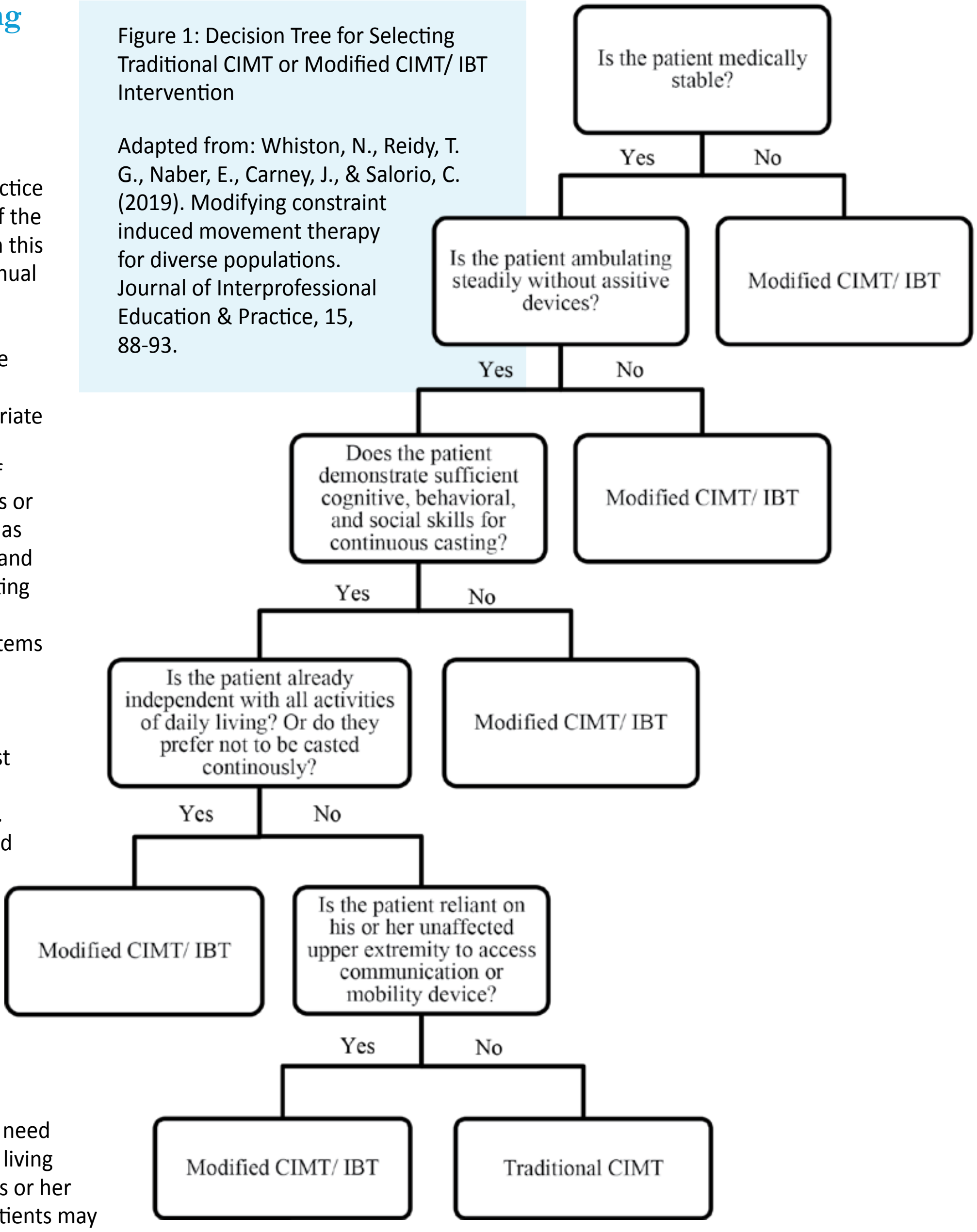
Collaborative Decision Making

Given that both traditional and modified protocols of IBT and CIMT have a strong evidence base, a number of factors may influence clinical decision-making in collaboration with a patient. As is best practice in all settings, the goals and preferences of the patient should be the first consideration in this process[5]. If the patient has primarily bimanual goals, for example, opening containers or completing clothing fasteners, IBT may be the most effective way to provide intensive and specific practice of this skill. For this reason, IBT could also be the most appropriate choice when a patient has impairments in bilateral upper extremities[10]. Conversely, if the patient has one-side weakness, and his or her primary goal is a unimanual skill, such as increasing grip strength in their affected hand to hold items without dropping them, casting may be the best approach to incorporate repetitive practice of sustaining grasp on items throughout his or her daily routines.

In addition to patient goals, a number of patient-related factors may lead a therapist to decide to use a modified CIMT protocol that does not involve continuous casting[11]. In some cases, the use of a constraint could impact the patient's functional mobility, communication, or independence with ADLs outside of therapy settings. For example, if a patient uses a cane or walker to ambulate, they may not be able to access these devices to walk while casted. Wearing a cast full time also could limit a patient's ability to manage clothing or complete hygiene in the bathroom independently; they may need a caregiver to assist with activities of daily living typically completed independently with his or her less affected arm and hand. Thus some patients may prefer an IBT program or modified CIMT program to allow them to retain their independence especially if they do not have a caregiver available to assist them outside of therapy sessions. FIGURE 1 provides a decision tree a clinician may use to determine if a patient is more appropriate for traditional CIMT with continuous casting or a modified CIMT or IBT program.

Figure 1: Decision Tree for Selecting Traditional CIMT or Modified CIMT/ IBT Intervention

Adapted from: Whiston, N., Reidy, T. G., Naber, E., Carney, J., & Salorio, C. (2019). Modifying constraint induced movement therapy for diverse populations. Journal of Interprofessional Education & Practice, 15, 88-93.



Focus on Function: Bimanual Activities and Generalization of Skills

When using traditional or modified CIMT in intensive therapy to improve the patient's more affected UE function, it is important to incorporate structured repetitive bimanual practice to integrate newly acquired or refined skills into daily routines[9,10]. For example, using a patient's increased grip strength to open a marker, or open a medicine bottle will facilitate daily use of their more affected UE and increase independence with functional activities. If a clinician targeted refinement in fine grasps during CIMT, the bimanual practice may be focused on opening a snack bag, holding paper while cutting with scissors, or fastening shirt buttons.

Focusing on functional bimanual activities that can be incorporated into a patient's daily routine will allow for regular practice with the patient's more affected UE to continue to strengthen and refine skills[7,9].

A clinician should provide a home program at the end of the intensive therapy bout to help to transfer skill development to the home environment. It is important to remind the patient and caregiver that consistent, success oriented practice that is naturally integrated into functional daily routines is the most effective way to continue to progress skills[9]. Using the functional bimanual activities that were practiced and mastered in therapy sessions is a great place to start for the patient's home program. A clinician should provide strategies to complete the activity and suggestions to grade the activity up or down via a written home program, demonstration, or audio visual materials. Patients and caregivers may request different methods of training for carryover at home depending on learning styles and availability.

Summary

Intensive UE therapies are supported in research and clinical practice to shape and refine skills of a patient's more affected UE. Clinicians use therapeutic reasoning to determine the most appropriate dosage, timing, and type of intensive bout of therapy based on patient and caregiver goals and needs as well as patient factors. In some instances therapists may utilize alternative options such as a modified therapy program, use of a therapeutic home program or rehabilitation technology facilitated by a caregiver to provide intensive therapy. Regardless of the type of intensive therapy provided to the patient, the application of new skills to functional daily activities and training in a home program is key to carryover and sustained progress.

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Constraint-Induced Movement Therapy via Telehealth Builds Client Autonomy

Lynne V. Gauthier, PhD
Rachel Proffitt, OTD, OTR/L
Alexandra Borstad, PT, PhD
Kristina M. Kelly, PT, DPT, EdM

Behavioral intervention is an essential component of Constraint-Induced (CI) Movement therapy (TABLE 1). It results in more habitual use of the paretic arm for daily activities,[1,2] which may in turn drive brain plasticity[3] and quality of life improvements.[4] Yet, therapists struggle with how to implement it given time and reimbursement constraints.

A flipped model of care, in which motor practice is largely self-managed at home and treatment sessions emphasize behavioral change, can address these primary challenges.

Self-managed motor practice: Motor practice self-managed at home can be just as effective,[5] and frees up therapist time for behavioral intervention. Self-management can be done via traditional task-based practice. Alternatively, video games can make motor practice more engaging, structure and pace the rehabilitation program, automatically progress difficulty, and log progress. Reports can be shared with the therapist, enhancing accountability and providing data-driven insights. Gaming is effective[6] and embraced by the community-dwelling stroke population.[7]

Behavior change through telehealth: The behavioral interventions of CI therapy are particularly well-suited to telehealth delivery because problem-solving can occur while clients attempt daily activities in their own homes. Telehealth also enables shorter, more frequent meetings to enhance support/accountability, while also reducing cost. TABLE 1 describes a tested approach to delivering CI therapy remotely and at low cost.[5]

Reimbursement: Behavioral intervention can occur during task practice and be billed as Self-Care/Home Management Training, Neuromuscular Re-education, or Therapeutic Activities. It can also be delivered by a Psychologist and billed using Health and Behavior codes.

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Table 1. Implementation of CI Therapy Components Via Telehealth.

Videos explaining the approach can be found here: https://www.youtube.com/playlist?list=PLz_WMXyN3CKjNS9RWETBU9yQsRhr3x-Jd
Treatment materials can be found starting on page 33 of the following linked document:
https://drive.google.com/file/d/1WaCusAUR87zkPFqYgHz---OPJw2ChyrL/view?usp=sharing

CI Therapy Component	How to Implement
Motor practice	• Clients agree to use their weaker arm throughout their daily routine. • Motor task practice with the weaker arm for 20 - 60 minutes daily. This should be challenging and progress as the client improves. It may take the following forms: ○ A home program of functional task practice ○ A video game to automatically progress the therapy, monitor adherence, and provide feedback on progress. Games That Move You, PBC offers an in-home video game that delivers motor practice based on CI therapy principles.
Behavior change: Self-monitoring and accountability	• Clients identify specific components of activities within their daily routine that they can use the weaker arm to perform. Therapists construct a checklist for the client. Clients revisit this list daily and check off which activities they tried with the affected arm. • The Motor Activity Log (MAL) questionnaire[8] can be used to monitor the quality of arm use for several daily activities. It is free to use and has a therapeutic effect when coupled with problem-solving (see below).[9] • Clients identify their own strategies to remind themselves to use their affected arm. This promotes buy-in and adherence. • Smart-watches that monitor everyday arm use can be added to draw awareness to asymmetries and provide reminders to use the affected side following periods of inactivity. • A restraint mitt has been used to discourage use of the stronger arm, but it has minimal impact[10] and clients dislike it.
Behavior change: Problem-solving	• Therapists prompt clients to formulate *their own* strategies to incorporate the affected side into daily activities. When clients struggle with this, therapists can offer potential strategies to pick from. The client tries the listed strategies for homework. • Strategies are revisited to assess how well they worked • Imperfect, yet functional, movement is encouraged. Therapist monitors for safety and biomechanics to prevent secondary injuries. • Brief (e.g., 15 minute) sessions that occur several times per week solidify behavior change and improve adherence.[5]

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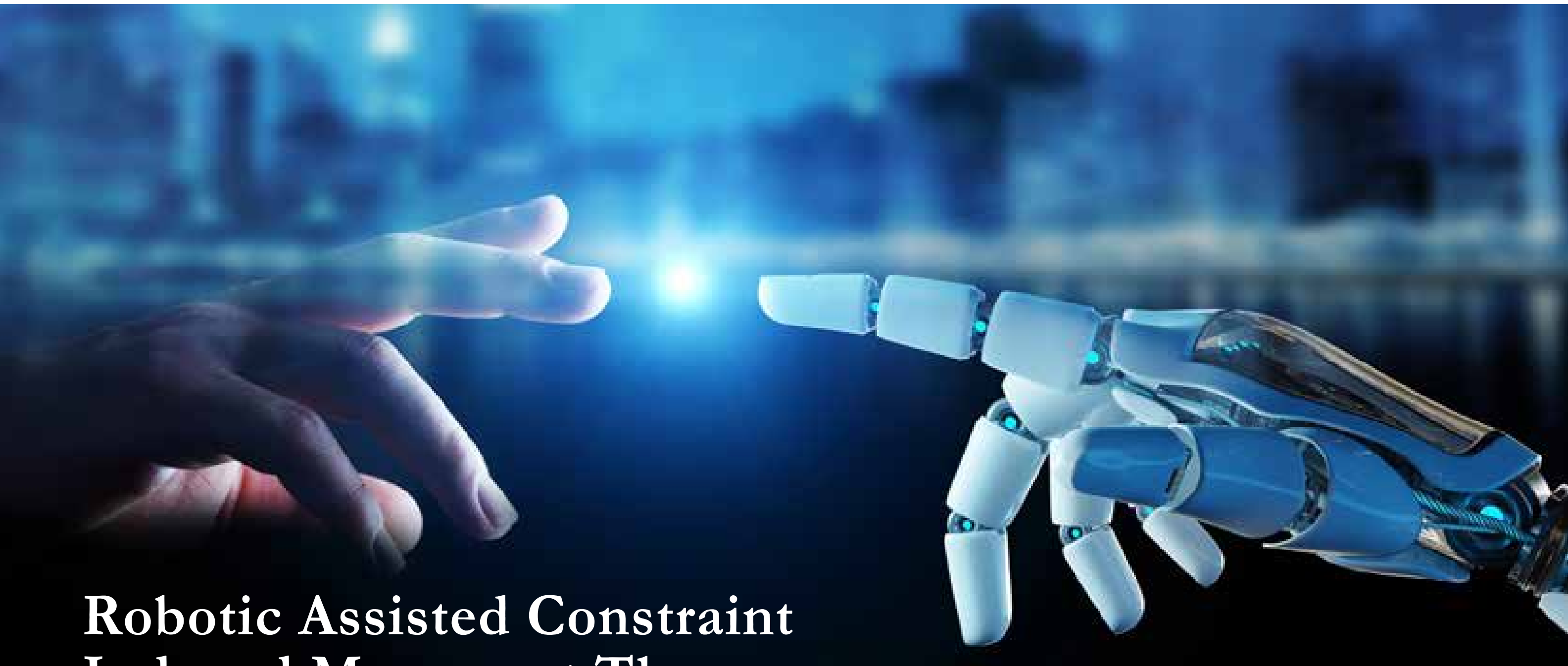

Robotic Assisted Constraint Induced Movement Therapy

Stephen K. Trapp

A range of robotic devices addressing hemiparesis exist on the market. These systems are often inspired by modified principles of therapies traditionally offered through direct clinician care. One therapeutic approach that has demonstrated value in addressing limb functioning following neurological injury or disorder is constraint-induced movement therapy (CIMT). Unfortunately, there are barriers to person guided CIMT, including intensive practice requirements and a range of costly clinical resources associated with the treatment[6]. For adults and children, salutary CIMT outcomes require a patient to maintain motivation and engage in the therapy with precision[3, 6]. To address some of these barriers, innovators are creating robot-assisted CIMT interventions for limb function rehabilitation[4]. These machines leverage a range of features, such as sensing technology and gamification to individualize tasks, enhance adherence, and perform treatment actions with accuracy and consistency. Accordingly, this technology offers great potential for a range of rehabilitation modalities that require repetitive task precision. Most robotic devices on the market are assistive in nature and address a range of functioning level needs, such as passive support and guided motion. Other devices seek to restore function through more intensive assisted therapies. Few CIMT-dedicated robotic devices currently exist on the market, though many systems include CIMT-inspired features or require a therapist to purposefully include modified CIMT principles into therapies when using these systems. Cochrane systematic reviews of the literature indicate promising therapeutic value for robot-assisted rehabilitation treatments among adult end users[5] and there is indication that pediatric populations will benefit from this technology as well[1, 2]. Accordingly, the research and development of robotic systems have seen a notable increase recently.

Despite this optimism and growth in development, concerns exist regarding the rigor of the research and clinical application, such as availability of these robotic solutions in actual clinic spaces and the need for rehabilitation specialists to assist with the use of the technology[5, 7]. Together, robotic rehabilitation technology has developed traction as a valued clinical tool, but the diffusion of innovation pathway for CIMT robotic interventions has yet to move from bench to bedside in a robust and accessible way.

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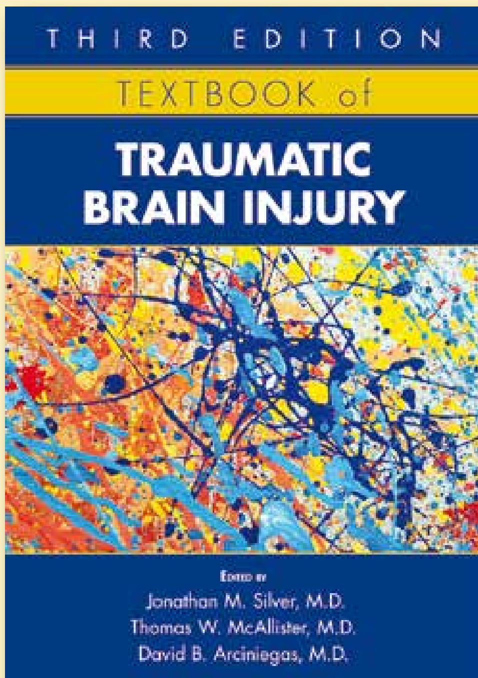

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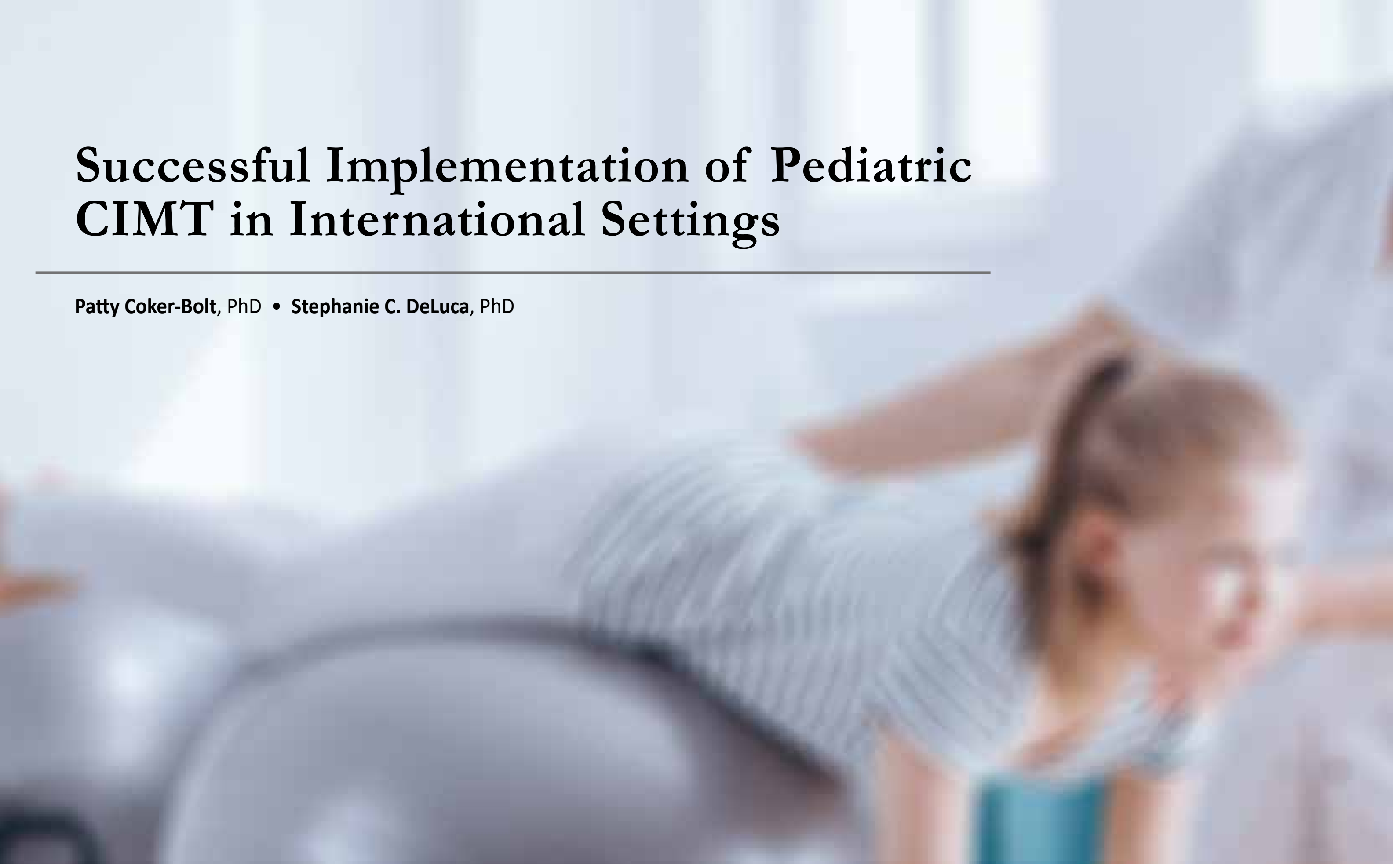

Successful Implementation of Pediatric CIMT in International Settings

Patty Coker-Bolt, PhD • **Stephanie C. DeLuca**, PhD

Introduction

Pediatric constraint-induced movement therapy (PCIMT) is a leading, evidence-based rehabilitation approach that has demonstrated efficacy in improving functional skills and abilities in children with hemiparetic cerebral palsy (CP).[1,2] Implementation of CIMT into practice remains a challenge, despite the robust evidence supporting its use. Anecdotal evidence suggests that clinicians are interested in CIMT but hesitant to use it.[3] Several studies have investigated barriers to CIMT implementation including a lack of confidence and knowledge and a lack of training in evidence-based CIMT protocols.[4,5] Patient related barriers include cognitive and physical impairments limiting a person's ability to engage in CIMT4 and clinicians concerns about patient compliance and safety.[5,6] Resource-related barriers include a lack of staff, time and equipment.[4-6]

A recent study by Christie et al.[7] surveyed clinicians from 17 countries including the United Kingdom, Australia, Denmark, Singapore, Norway and Canada to determine their proficiency in using CIMT. Results indicated a majority of clinicians felt comfortable delivering CIMT, yet less than half of the sample reported attending an external CIMT training course. Most respondents reported learning about (or becoming aware of) CIMT from journal articles and/or clinical guidelines. In addition, the fidelity of CIMT programs appears to be low based on respondents' self-reports, perhaps due to limited formal training. Clinicians who delivered individual CIMT programs reported great variation in terms of dosage and outcome measurements. Finally, there was lower frequency of using CIMT as an intervention in practice, implying that many adults and children who have experienced stroke and brain injury are missing out on this effective upper limb intervention.

The current research on PCIMT has described barriers and challenges to implementation, yet few studies have focused on successful implementation in clinical practice settings. In addition, few studies have addressed how PCIMT can be applied in the low and middle-resource countries where models of healthcare delivery vary. This is unfortunate as lower-resource settings and countries boast a disproportionate burden of neurological disorders in both adults and pediatrics.[8] The World Health Organization currently estimates that there are 150 million pediatric patients with a developmental disability worldwide, with increased incidence in developing countries around the world.[8] Of these, there are as many as 4 per 1,000 estimated children with injuries to the developing brain, including CP.[9] Cerebral palsy in particular is five to 10 times more common in lower-resource countries.[10] This extreme need makes it critical to consider best practices for implementing evidence-based rehabilitation in low and middle-resourced countries.

This article will highlight the successful implementation of pediatric CIMT in countries with non-Western cultures. We will discuss successful training and implementation strategies which expanded the delivery of pediatric CIMT in different healthcare settings.

Assuring Fidelity During Collaborations with International Partners

In Christie, et.al.[7] concluded that "CIMT is being used globally but not always with fidelity to the original trials. A range of strategies are needed for improving clinicians' knowledge and skills to increase the frequency of program delivery and enhance program delivery with (increased) fidelity." (p. 407).

Figure 1. Video Recorded Session of Therapist at the Hanoi Rehabilitation Hospital Providing CIMT to Assure Fidelity

In our international experiences we have learned that clinicians across the globe are inclined towards CIMT because of its evidence-based history, and we have learned that successful training can result in successful delivery of PCIMT. As with almost all good teaching processes the foundation of training efforts must be an interdisciplinary collaborative exchange of information built on a foundational relationship. CIMT like any good therapy requires strategic investments. In both Ethiopia and Vietnam, we partnered with large in-country institutions; CURE International in Ethiopia and Humanity Inclusion in Vietnam. We then presented the state-of-the evidence surrounding intensive therapies, which included, but was not limited to pediatric CIMT. We delivered this education via didactic presentation of translated reading material, presentations, and video examples. In both countries, we also used direct hands-on training, where we brought children with hemiparesis and their families in from the community. The children and families became part of the training process as therapists learned the principles associated with the efficacy of PCIMT. Training sessions included the use of operant conditioning and how to use positive reinforcement with appropriately timed and varied schedules of reinforcement. These principles are presented in every psychology 101 course in westernized countries, but regardless of setting it should never be assumed that clinicians can easily translate these practices into the therapeutic process. The feedback we received from participants was that direct hands-on modeling of therapeutic activities during these in-country training sessions were invaluable.

We followed up the education of therapeutic principles of CIMT by then 'listening'. Question and answers were welcomed and encourage at all points in the training, but each and every day – we listened. What were the available resources? How might clinicians build models of CIMT for their clinical settings? Who were the clinicians who would deliver CIMT?

In many countries, the designations between rehabilitation specialties are different and the delivery of intensive therapies are based on very different models of care than we are accustomed to in Western healthcare systems. Most importantly --- we listened to understand how we could help their process to develop to allow for the delivery of a high quality CIMT program in their healthcare setting. The needed componential makeup of CIMT is far from a resolved issue scientifically, but contextual needs were heard.

Use of Fidelity Measures and Assessment Tools

With adaptations, we also helped design in-country measurements of outcomes. For example, the Pediatric Motor Activity Log[11] and the ABILHAND[12] were translated and encouraged to be used as pre and post-assessments. Clinicians needed to understand if their models of pediatric CIMT were in fact successful. In addition, we talked about measuring treatment fidelity just as Christie describes to enhance implementation. In both Ethiopia and Vietnam we were lucky enough to follow our training with research studies to confirm the efficacy of CIMT, as well as measure effectiveness of implementation or treatment fidelity.[2,13] The fidelity tool we adapted was developed to measure the 5 core components of pediatric CIMT we put forth in prior publications.[1,14] We had previously defined the operant conditioning process in CIMT through the MR3 Cycle, where movements (random or purposeful), are reinforced, repeated, and refined. We used the MR3 Cycle within the fidelity tool and measured this process via video recording (FIGURE 1). Six operant conditioning aspects were measured on a three-point scale, unacceptable, minimal standards, or high standards of delivery. With our Vietnamese colleagues, therapists at two pediatric rehabilitation hospitals in Vietnam were able to deliver high quality CIMT with acceptable fidelity using this fidelity measure.

Models to Improve the Translation of PCIMT in International Settings

We successfully applied a translational and implementation framework to build capacity for PCIMT in both Ethiopia and Vietnam where healthcare systems and resources are different from countries where this intervention has been more widely accepted and delivered. Each training program met the goal of creating locally feasible, culturally relevant forms of PCIMT which were implemented with fidelity within the context of their local hospitals and clinics. TABLE 1 provides an example of the PCIMT models developed by practitioners in Ethiopia and Vietnam.

Table 1. Models of PCIMT Programs Developed by Practitioners in Ethiopia and Vietnam

"Signature" CIMT ***investigated in most studies*	Ethiopian Model (Coker-Bolt, DeLuca, & Ramey, 2015)	Vietnam Models (DeLuca, Coker-Bolt, Shriek, Roberts, & Ramey, 2019)
Constraint of less involved extremity with univalved cast	Constraint of less involved extremity with univalved cast or orthotic + mitt	Constraint of less involved extremity with orthotic + mitt
High dosage (beyond typical therapy schedule) Dosage = 60 to 120 hours	High dosage (beyond typical therapy schedule) Dosage = 40 hours	High dosage (beyond typical therapy schedule) Dosage = 30 to 72 hours
Use of shaping techniques with repetitive practice with task variation	Use of shaping techniques with repetitive practice with task variation	Use of shaping techniques with repetitive practice with task variation
Sessions take place in the natural environment	Sessions in clinic and at home with therapist and parent who was trained to deliver part of the CIMT program. Toys sent home in a backpack to encourage additional practice time at home with parent	Sessions in clinic and parents were trained to deliver part of the CIMT program
Transition or discharge package was provided at end of CIMT program	Transition or discharge package was provided at end of CIMT program	Transition or discharge package was provided at end of CIMT program

Evidence-based interventions can be implemented in international settings where resources, personnel, and healthcare delivery models vary. A carefully developed and iterative process can be used to inform local providers about the history and literature on PCIMT, educate practitioners on the key elements of PCIMT, and problem-solve collaboratively to create effective PCIMT models to improve the quality of rehabilitation services available to children with disabilities and their families in international settings.

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Author Bios

Patty Coker-Bolt is a Professor in the Division of Occupational Therapy at the Medical University of South Carolina (MUSC). She received an undergraduate degree in special education from the Pennsylvania State University in 1989 and her OT degree from the MUSC in 1998. She has over 23 years of experience, specializing in the treatment of high-risk infants and children with neuromuscular disorders such as cerebral palsy (CP). Her research has focused on interventions for children with CP and includes a pediatric handbook on constraint-induced movement therapy. Dr. Coker-Bolt has been involved in global initiatives in South Africa, Romania, Uganda, and Nicaragua. She completed grant funded projects to train therapists in Ethiopia and Vietnam. She was selected as a Fulbright Specialist to work with the Episcopal University of Haiti in 2016 and completed a Fulbright Specialist award to develop inclusive community and sport opportunities for children with disabilities in Kazan, Russia in 2019.

Stephanie C. DeLuca, PhD is a developmental scientist who has examined the impact of intensive neurorehabilitation treatments on children and adults with neuromotor impairments. Dr. DeLuca's interdisciplinary research has included numerous phase II and phase III trials on Pediatric Constraint-Induced Movement Therapy (PCIMT), where she was instrumental in developing a signature form of PCIMT called ACQUIRE Therapy. Dr. DeLuca is an Associate Professor at the Fralin Biomedical Research Institute with additional appointments in the Department of Pediatrics and the School of Neuroscience, Virginia Tech. In addition, Dr. DeLuca serves as a member of the National Advisory Board on Medical Rehabilitation Research for the Eunice Kennedy Shriver National Institute of Child Health and Human Development and on the Research Committee for the International Alliance of Academies of Childhood Disabilities.

events

2021

December

9 -10: *Inaugural Virtual Conference on Disorders of Consciousness*, December 9-10, Virtual format. For more information, visit www.internationalbrain.org.

2022

February

11: *Traumatic Brain Injury Conference*, February 11, Virtual Platform. For more information, please visit www.events.myconferencesuite.com/TBI2022.

March

31 – 3: *AOTA Annual Conference & Expo 2022*, March 31 – April 2, 2022, San Antonio, Texas. For more information, visit www.aota.org.

September

21-24: *Fourth International Conference on Paediatric Brain Injury*, September 21 – 24, New York, New York. For more information, visit www.internationalbrain.org.

21-24: *2022 NABIS Conference on Brain Injury*, September 21 – 24, New York, New York. For more information, visit www.internationalbrain.org.

21-24: *2022 Conference on Medical & Legal Issues in Brain Injury*, September 21 – 24, New York, New York. For more information, visit www.internationalbrain.org.

October

20 – 23: *AAPMR Conference*, October 20 – 23, Baltimore, Maryland. For more information on the meeting, visit www.aapmr.org.

November

8 –11: *99th ACRM Annual Conference*, November 8 – 11, Chicago, IL. For more information, visit www.acrm.org.

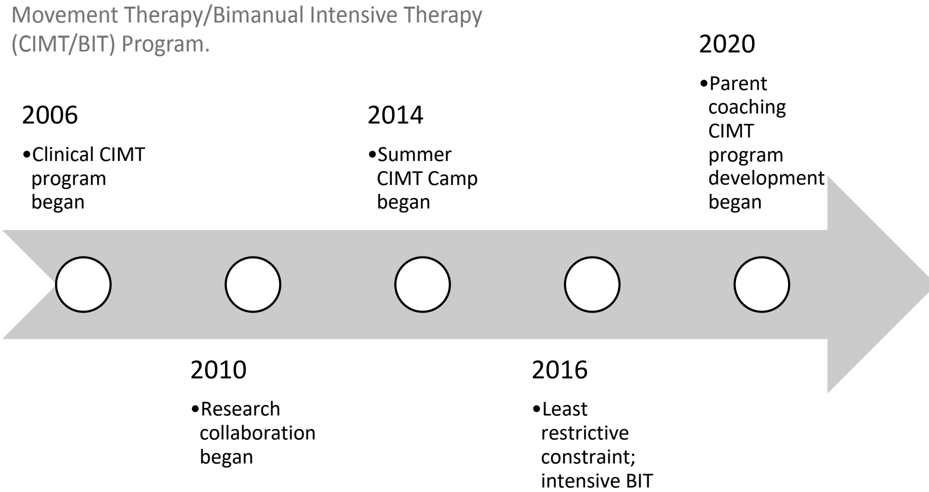
Designing and Implementing an Evidence-Informed CIMT Program for Infants using Principles of Parent Coaching

Sara O'Rourke, MOT, OTR/L, BCP • **Nancy Batterson**, OT/L, SCFES, CLC
Kelly Tanner, PhD, OTR/L, BCP

Introduction

Constraint induced movement therapy (CIMT) is strongly recommended for children with unilateral cerebral palsy (CP) under two years old.[1] Multiple models of CIMT exist in the literature and have used a variety of constraint techniques, dosages, and either a therapist or parent as the primary individual delivering the intervention. The objectives of this article are to 1) review the rationale for the use of parent coaching for young children with CP, and 2) describe the development of an evidence-informed parent coaching-focused CIMT program for children under two.

Figure 1. History of the Nationwide Children's Hospital Clinical Constraint Induced Movement Therapy/Bimanual Intensive Therapy (CIMT/BIT) Program.



Background

Nationwide Children's Hospital (NCH) is one of the largest freestanding pediatric hospitals in the United States. NCH offers developmental occupational therapy services at eight clinical sites around the Central Ohio area and employs approximately 40 practitioners. Evidence-based practice is infused into the department's culture, with multiple tracks for staff members to engage in knowledge translation and quality improvement. NCH has had a clinical CIMT program, which was initially modelled on the ACQUIRE approach,[2] since 2006. The program has continually evolved with the scientific literature (see FIGURE 1).

For example, programming expanded to include bimanual intensive therapy,[3] a three day per week in-clinic option, and a group-based camp model for older children.[4–6] After an extensive literature review completed in 2016 which showed lack of published studies comparing types of constraints in young children,[3] the program shifted to using the "least restrictive constraint" needed to accomplish therapeutic goals. The therapist and parent(s) select the type of restraint for each patient using a shared decision-making process. The CIMT program continues to adapt to reflect the latest literature while also meeting the needs of patient families. Recently, this has included the development of a parent coaching-focused program.

Why parent coaching?

Parent coaching has long been used as a delivery model across early intervention programs for children with prematurity and other risk factors.[7] The rationale is that by involving parents directly in therapy sessions, the child will experience a higher amount of skilled interaction throughout the day. Therapists work with parents to incorporate therapeutic activities into daily routines and to enrich the child's natural environment during critical developmental periods. For infants with CP, there is emerging evidence regarding the effectiveness of interventions involving parent coaching.[8] Clinical practice guidelines for occupational therapy highlight the importance of incorporating parent coaching when addressing motor challenges in young children.[9]

Multiple models for early CIMT exist in the literature (TABLE 1).[10,11] While a parent education program component is included in almost all CIMT models, many are characterized by frequent (typically daily) therapy visits. There is an emerging body of literature supporting parent coaching focused CIMT, with improvements in both movement quality and unimanual and bimanual skills seen in comparison to control interventions.[12,13]

Table 1.

Author/Year	Sample Size & Age	Type of Constraint & Total Wear	CIMT Direct Therapy Time	CIMT Parent/Home Program Time
Coker et al. (2009)	*n*= 1 9 months	**Type:** Resting hand splint covered by a soft cloth mitt **Total wear:** 1 hour a day for 30 consecutive days	1 hour of OT or PT per day, 4 days a week for two 2-week bouts (2 weeks of conventional therapy between bouts)	1 hour a day for 3 days a week
Cope et al. (2008)	*n*=1 12 months	**Type:** Non-removable short cast worn **Total wear:** 2 weeks	8 hours of OT/PT per week for 2 weeks	None specified
Eliasson et al. (2018)	*n*=18 (intervention) *n*=13 (baby massage control) 3-8 months	**Type:** Mitten or soft mitt **Total wear:** 36 hours	None; weekly OT home visit focused on parent coaching and supervision	30 minutes a day, 6 days a week for 12 weeks
Fergus et al. (2008)	*n*=1 13 months	**Type:** Soft removable mitt covering hand and wrist **Total wear:** 1st phase: 6 hours/day for 3 weeks 2nd phase: 4 hours/day for 3 weeks Decreasing wear of mitt 1 hour a week each week for 5 weeks	1 hour per week	1st phase: 6 hours a day for 3 weeks 2nd phase: 4 hours a day for 3 weeks
Lowes et al. (2014)	*n*= 5 7-18 months	**Type:** Long arm cast **Total wear:** 23 days	2 hours of OT 5 days a week; 23 days of cast wear and 4 days without cast for bimanual activities	1 hour of therapeutic activity per day
Maitre et al. (2020)	*n*=37 (intervention) *n*=24 (wait list control) 6-24 months	**Type:** C-Mitt (loose soft harness) **Total wear:** 6 hours a day; average of 38 hours a week	1 hour 1x week for 4 weeks	40-60 minutes a day
Reidy et al. (2017)	*n*=1 18 months	**Type:** Custom fabricated long arm splint **Total wear:** 2 hours a day for 20 sessions	1 hour OT/PT 3-5 days week for 20 sessions	1 hour of parent activity 3-5 days week for 20 sessions

Note: Coker P, Lebkicher C, Harris L, Snape J. The effects of constraint-induced movement therapy for a child less than one year of age. *NeuroRehabilitation*. 2009;24(3):199-208. doi:10.3233/NRE-2009-0469; Cope SM, Forst HC, Bibis D, Liu X-C. Modified Constraint-Induced Movement Therapy for a 12-Month-Old Child With Hemiplegia: A Case Report. *Am J Occup Ther*. 2008;62(4):430-437. doi:10.5014/ajot.62.4.430; Eliasson A-C, Nordstrand L, Ek L, et al. The effectiveness of Baby-CIMT in infants younger than 12 months with clinical signs of unilateral-cerebral palsy; an explorative study with randomized design. *Research in Developmental Disabilities*. 2018;72:191-201. doi:10.1016/j.ridd.2017.11.006; Fergus A, Buckler J, Farrell J, Isley M, McFarland M, Riley B.

Therapist-supervised CIMT delivered in the home is strongly recommended.[1]

In the absence of information from comparative trials of these different models of CIMT, clinicians are charged with using their clinical reasoning to match the patient with a CIMT model that will have maximum benefit.. The infant and family's schedule must be considered, along with their ability to travel to the clinic regularly, insurance status, availability of time off work to participate in an intensive program, arrangement of care for siblings, and plan for integration of therapeutic activities into daily routines.

This type of reasoning is consistent with Sackett et al.'s classic model for evidence-based medicine in which the best available literature is balanced with clinical expertise and stakeholder input.[14] Ultimately, interventions that do not work for a family are unlikely to be successful, and a flexible approach to CIMT is needed.

Based on the results of our literature review, a group of clinicians and leadership staff members convened to use rigorous principles of quality improvement to develop and implement the parent coaching focused CIMT program.

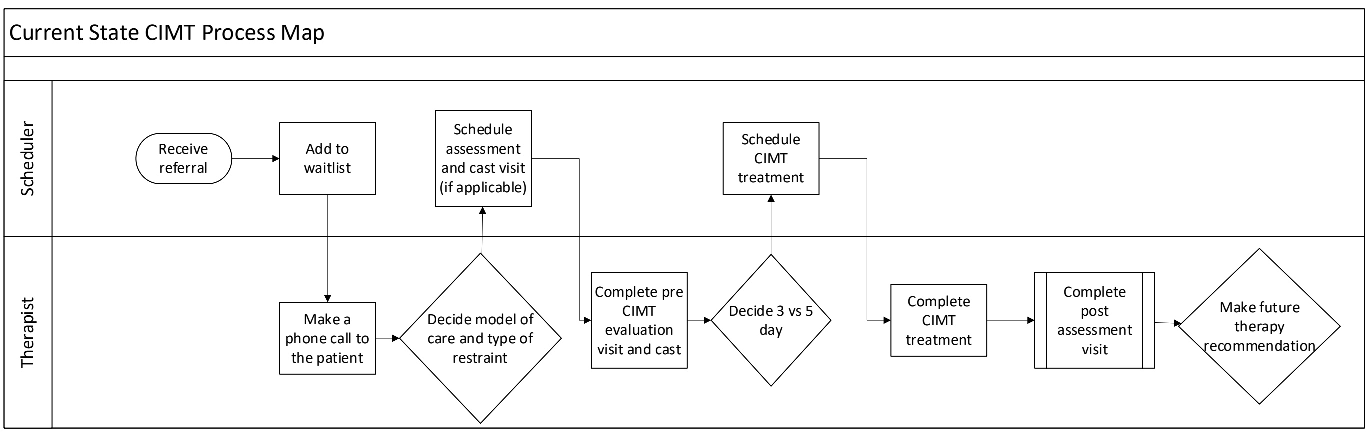


Figure 2. Current State Constraint Induced Movement Therapy (CIMT) Process Map

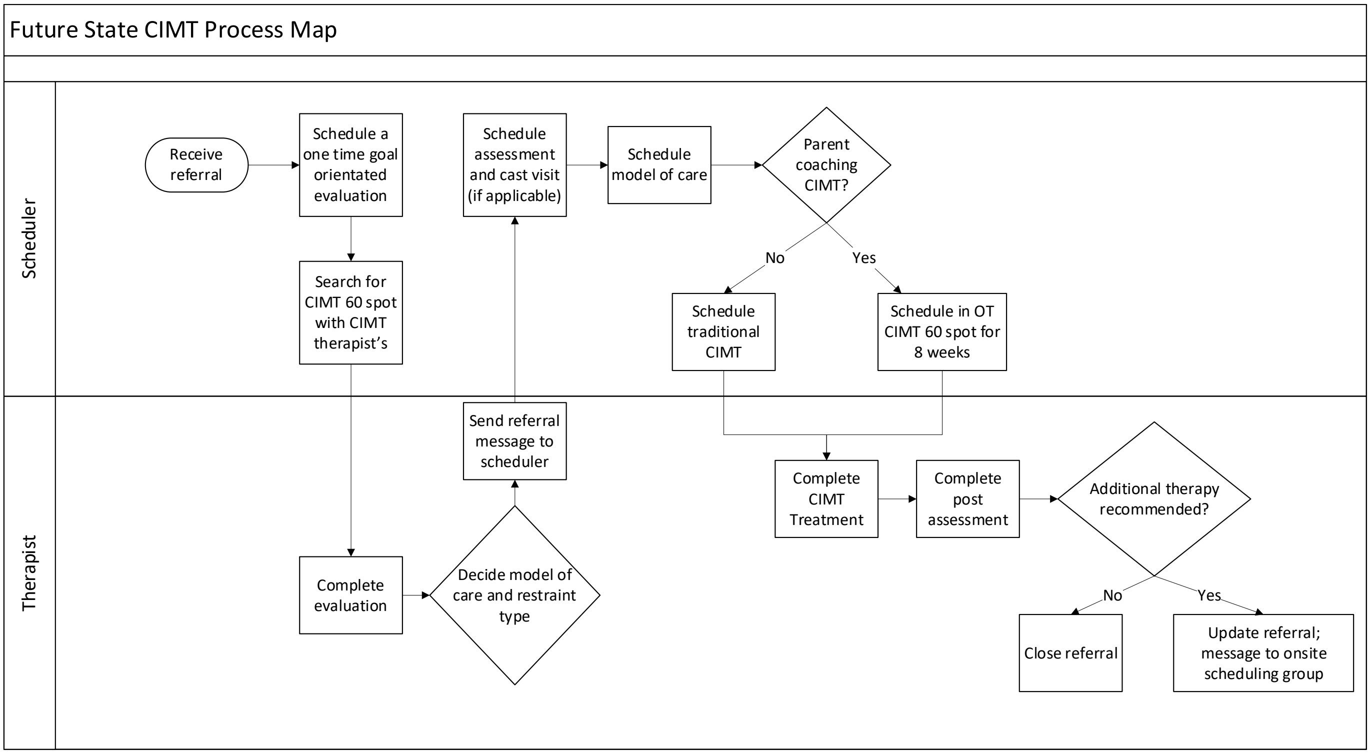


Figure 3. Future State Constraint Induced Movement Therapy (CIMT) Process Map

Following the Institute for Healthcare Improvement (IHI) Model for Improvement,[15] process mapping and brainstorming tools to map out the current (FIGURE 2) and future state (FIGURE 3) processes to develop the key driver diagram as a guide to implementation were leveraged (FIGURE 4).

Several areas for improvement were identified. Streamlining the referral process and adding a goal-orientated evaluation completed by a CIMT therapist allowed for more shared decision-making with stakeholders. These new processes were accompanied by decision-making pathways, resulting in a clear clinical tract for CIMT patients from the time of evaluation through the end of the program. Baseline data were collected to determine the percentage of children with hemiparesis seen in our department who received CIMT over the previous two years. The data revealed that among patients with hemiparesis enrolled in OT, only 4.75% accessed this model of care. The hypothesis is that CIMT is an intensive model of care, requiring many resources that may not be available to all families. As the parent coaching focused CIMT program continues to be developed, these metrics will continue to be followed to track patient access.

Quality improvement interventions will establish and sustain the new parent coaching focused model of CIMT. An affinity diagram to identify interventions was completed, with each process being paired with a pathway for implementation. Staff education, knowledge, and training is a key intervention. Fidelity with this new intervention will be ensured using standard departmental procedures including structured education, completion of clinical competencies, and chart audits. As the program is refined through Plan-Do-Study-Act (PDSA) cycles, the new program will then expand to all eight locations with the final programmatic goal being that every OT practitioner can deliver CIMT using principles of parent coaching to their patients with hemiparesis.

Communication with key stakeholders (e.g. referring physicians) and patient families is an important element of program development. Informational brochures aimed at these specific audiences can streamline initial communication of program structures and goals. Shared decision making can help align best evidence with the preferences and feasibility of those participating. For families and therapists participating in the program, resources such as standardized home exercise programs developed in conjunction with parent consultants can help ensure that communication continues to go smoothly.

Conclusion

As the parent coaching-focused model of CIMT for infants and young children with CP evolves, continual data collection will lead to additional quality improvement interventions to move towards our objectives. Fostering flexibility and resilience in clinical programs allows us to continue to adapt as the scientific literature advances. Practice-based evidence gleaned from clinical programs can, in turn, inform future research to move the field of CIMT forward.

Acknowledgements

Thank you to members of the Early CP COG and the members of Parent Coaching CIMT Implementation Group for contributing.

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Author Bios

Sara O'Rourke, MOT, OTR/L, BCP is the Outpatient Occupational Therapy Program Manager at Nationwide Children's Hospital. She manages a staff of over 40 occupational therapy practitioners at 8 sites across the city. She has experience as a clinical leader and occupational therapist, with expertise in evaluating and treating children with cerebral palsy. She has engaged in scholarly work with this population and has been part of multiple quality improvement activities surrounding pediatric constraint induced movement therapy.

Nancy Batterson, OT/L, SCFES, CLC is a staff occupational therapist at Nationwide Children's Hospital. She has extensive experience in evaluating and treating children with cerebral palsy (CP) and has led an evidence based outcome group looking at best practice models to use in therapy for children under one year with or at risk for CP. Nancy has presented at the state and national level on topics related to cerebral palsy, CIMT in infants and toddlers and feeding.

Kelly Tanner, PhD, OTR/L, BCP is a Clinical Researcher at Nationwide Children's Hospital in Columbus, OH. She is also a faculty member in the Leadership Education in Neurodevelopmental and related Disabilities (LEND) program at The Ohio State University Nisonger Center. Dr. Tanner's work focuses on implementing best practices for pediatric rehabilitation, particularly for young children with brain injury.

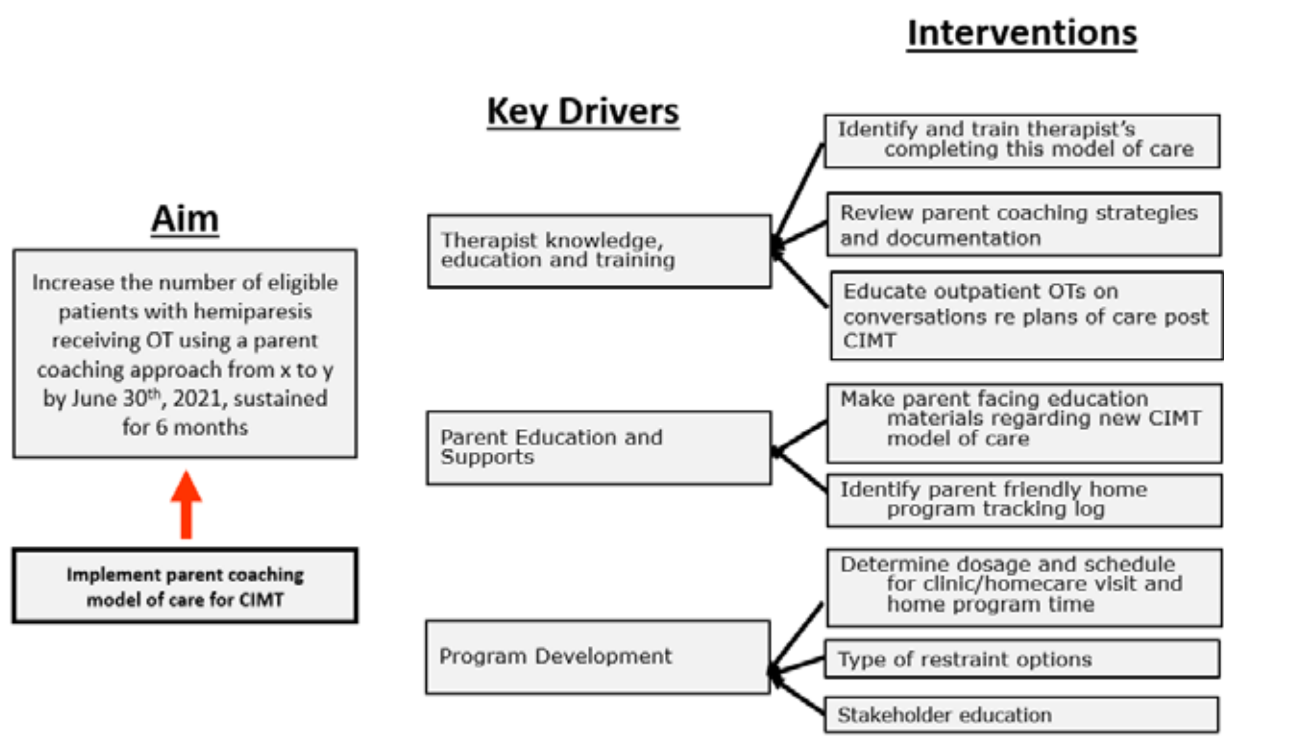


Figure 4. Key Driver Diagram

Pictured: Georgie

patient and parent interviews

Mary Rebekah Trucks, MS, OTR/L • **Dory A. Wallace**, MS, OTR/L

ACQUIRE P-CIMT is a signature form of pediatric constraint induced movement therapy. **ACQUIRE** stands for **Acquisition** of new motor skills through **Continuous** practice and shaping to produce **Quality** movement of the **Upper** extremity through Intensive therapy and Reinforcement in **Everyday** patterns and places. ACQUIRE P-CIMT includes 5 signature components: a constraint on the non-affected upper extremity, high dosage of therapy (delivered for many hours per day, across multiple days a week for multiple weeks), the use of shaping or operant conditioning techniques to guide treatment activities, treatment is delivered in the natural setting, and the "transition package" provided post therapy for maintenance of gains..

Keya experienced a stroke in utero, causing left-sided weakness. When she was just 13 months old Keya participated in her first round of ACQUIRE P-CIMT. Keya wore a cast on her right arm to focus on gaining ability with her left hand. She has completed multiple epochs of treatments and is now 17 years old, enjoys playing tennis and is an aspiring photographer. When asked about her experiences, she shared the following:

What was the hardest and best part of participating in an intensive therapy program?

The hardest part was "doing therapy the entire day. It's more mentally exhausting than you think." The best part was: "I've seen other kids and you can tell that they had a stroke because their hand stays fisted at their side and they have a hard time carrying their books. I don't have those issues and can see that I've put in work and it did something and I'm able to do all the things that I can do now. There was never anything I decided to practice, and I wasn't able to do by the end of treatment. That wasn't an option in my head, I thought, 'I'm getting it'."

How did you feel about wearing a cast?

"I didn't like it, it was itchy, uncomfortable, and I wanted to use my hand. Once I got older I could see why I was wearing it, so I could focus on my other hand." When the cast was on "I started using my left hand more. It just became easier."

Do you think P-CIMT was helpful and would you consider doing it as an adult?

"Yeah, I think it was really helpful. Any kid who has the opportunity to, I think should. Even a year can help too or help parents see what they need to do too is important. I think I will probably do it as an adult."

Georgie, who has a diagnosis of left sided hemiplegia secondary to a stroke, and her mother Karla participated in their first ACQUIRE P-CIMT program to focus on gaining ability with her left hand when Georgie was 18 months old. Georgie has participated in multiple epochs of treatment. She is now 16 years old, enjoys singing and musical theater. When asked about their experiences they shared the following:

How did you (Georgie) feel about wearing a cast during treatment?

"I didn't really like it, but I know it was good to use my weaker arm without my strong hand, but I can definitely say I didn't like it. I remember just forgetting (about the cast) when I was hanging out I forgot it was there. I think the therapy and the casting made it (my weaker arm/hand) looser and I think I could use it a little bit more."

What was the best part of participating in an intensive program?

"Definitely gaining strength in my weaker (arm/hand) that I wouldn't have gained without therapy so I could use both hands. After the treatment I definitely feel stronger and able to use my hand definitely more."

Do you have to remind yourself to use both of your hands?

"I think it's a mix of both. Sometimes I'll be doing something and just using my right hand and my brain tells me that I could use my left hand too. But then sometimes I use both, like when I carry my laundry basket, I automatically use both hands. I use it a lot when I get ready. I use it a lot when I do the dishes. I use it when I do my laundry."

Are there things about P-CIMT that you (Karla) feel make it different from traditional therapy?

"I think the expectations are different, the ACQUIRE program has greater expectations of the sky's the limit; let's do everything you can possibly do versus other therapists focusing on function (with her dominant hand) and not capability (of both hands)."

What concerns did you have about Georgie participating in a P-CIMT program i.e. intensity?

"When you talk to adults they ask, "how do you do that?!" You can do it, and your child will be fine. The days would go by quickly and the next thing you know, you're thinking how am I already in week 3 and the cast is coming off. The hardest part is that it's not covered by insurance*. I would love to see it go from investigational to a standard level of care. Because it clearly works and I think that a lot of kids would benefit from it and a lot of OT's out there if they could be exposed to that when they are going through training, it would raise their expectations of what these kids can do."
*(*Insurance coverage for pediatric CIMT varies depending on insurance, setting in which therapy is delivered, and dosage.*

Clinics encourage interested families to work within their benefits to minimize out of pocket costs.)

How do you think P-CIMT changed Georgie's abilities and do you think this would have occurred without this intervention?

"I think what Georgie gained is that it gave her the mindset that there are no limitations for what she can try to do. And then just knowing that if she wants to accomplish something that through regular practice, she can gain that skill."

Three years after a traumatic brain injury, at the age of 25, Steven participated in ACQUIRE CIMT delivered 4 hours a day, 5 days a week for 4 weeks, with a cast). In an effort to seek out further rehabilitation, Steven found the ACQUIRE program through independent research and his family's support. When asked about his experience, he shared the following:

Was CIMT helpful?

"For sure. Going into therapy I just was going about my daily life not aware of my left arm and didn't think I could use it for anything. Getting into therapy with you all, simple daily life skills using my left arm made me realize my left arm is there and even though it doesn't function the same and I can't wiggle my fingers like my right hand, I can still use it however I can: turning on the water faucet, sticking my toothbrush in my hand, just little things etc. The biggest thing was realizing my left arm is still there and it may not be fully functional but it's still a part of my body."

Did you feel the cast was helpful in the process of CIMT?

" I definitely do. (It) forced me to use my left hand as much as I could and it just reinforced the fact that I still have a left arm and hand attached to my body. The cast helped to decrease the tightness in my arm and hand starting at my shoulder and moving down."

Would you participate again and would you recommend to others?

"Oh for sure. It's often crossed my mind that I wish we could get the funds to get another round of therapy. I feel like my left hand/arm has reached a point where the therapy would be beneficial again. For others I would definitely recommend it, even if you don't get full functionality back, it's something that's going to be beneficial."

Jenny and Brad are the parents of 5 year old twin boys, Clark and Dudley. Their son, Clark, experienced a grade IV hemorrhagic stroke in the perinatal period, and was diagnosed with right hemiplegia when he was 8 months old. This lead his parents to seek out the most beneficial and evidence based treatments for Clark. The whole family traveled from England for Clark to participate in his first intensive treatment when he was 18 months old and have returned for multiple repeat treatments since then. When asked about their experiences, they shared the following:

What made you decide to participate in a P-CIMT program and did you have any concerns?

"I worried at first about him being able to do what you wanted him to do, but your program gives him success. You play and change it up. We knew that this was the right thing to do. We felt nothing but positive. Nothing will stop us. It just seemed like such a no brainer. Yes, it's expensive, it's non-invasive, and it's got such proven results… It's just a wonderful experience."

Were you anxious about Clark wearing a cast and do you feel it had an impact on his emotional well being?

"We were so nervous about it, but within 5 minutes he was laughing and it was fine."

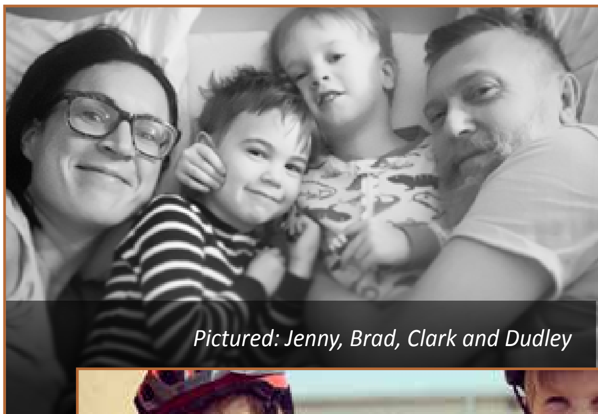
Did participation in a P-CIMT program change your expectations of Clark's potential abilities?

"It turned it around on its head for sure. With practice and determination I've seen him do a lot of things that I thought I would never see him do. He blew me away what he achieved, couldn't believe it, made us re-evaluate. We have a really good mindset in Clark now. Out of the blue he will come up to us and say, "look what I'm doing with my right hand" We say it so often, okay we might not have been lucky in what's happened to us but actually we've been so lucky to discover CIMT and meet the people we've met and what you do for everyone. It's been an amazing journey, we wouldn't change a thing."

About the Interviewers

Mary Rebekah Trucks, MS, OTR/L is a senior occupational therapist and research faculty at the Virginia Tech Fralin Biomedical Research Institute in Roanoke, Virginia. She has over 20 years of experience in the research and clinical implementation of the signature ACQUIRE form of Pediatric Constraint Included Movement Therapy (P-CIMT) and training therapists in its application.

Dory A. Wallace, MS, OTR/L is a senior occupational therapist and researcher at the Virginia Tech Fralin Biomedical Research Institutes Neuromotor Research Clinic in Roanoke, VA. She has over 16 years of experience in the research, clinical implementation, and therapist training of ACQUIRE P-CIMT.



Pictured: Jenny, Brad, Clark and Dudley

Pictured: Clark and Dudley

Group Based Protocols in Constraint Induced Movement Therapy

Nicole Whiston Andrejow, MS, OTR/L • **Erin Naber**, PT, DPT

In traditional intensive programs, patients participate exclusively in individual therapy sessions, but some modified programs have offered group therapy sessions to patients. In these group programs, the patients may exclusively participate in group sessions, or participants may have group sessions to supplement individual therapy sessions. A number of studies have reported positive functional outcomes following group-based constraint induced movement therapy (CIMT) for children with hemiplegia[1,2] and adults post-stroke[3]. In addition, Doussolin et al (2018) reported improved upper extremity functional outcomes in adults post-stroke who participated in group versus individual sessions of the same dosage[4].

Potential Benefits and Challenges of Group Therapy

There are a number of potential benefits to group-based interventions which include psychosocial factors such as improved motivation when working in collaboration with peers and the support provided by other group members with similar goals[1,3]. In addition, group-based therapy is typically less expensive. Decreased cost improves patient access to care. Group-based programs further improve access to CIMT by allowing multiple patients to receive intervention in the same timeframe[1].

Potential disadvantages of groups include decreased ability of therapists to provide 1:1 physical facilitation and postural corrections of compensatory patterns, which may impact the shaping of new skills. Additionally, it may be difficult to address the needs of patients that require assistance with or have specific goals that require privacy such as dressing and toileting. The use of trained aides, limiting of group size, and grouping patients with similar goals and ability levels may assist in providing appropriate guidance and assistance to each group member[1].

When developing a group-based protocol, clinicians may develop a set of criteria to guide selection of patients. Pediatric patients who are old enough to attend school, have had other group experiences, or interact with peers appropriately may be better suited for group-based therapy than young children, patients with maladaptive behaviors, or patients with limited attention or cognition. Patients who require 1:1 assistance with therapy tasks may make more progress in an individual therapy session rather than a group therapy session. Patient selection can also be limited by insurance coverage, as some insurance benefits may not cover group billing codes and may limit the number of patients in the group. Individual state practice acts may also put limits on the number of patients that can be in a group.

To provide assistance or facilitation to shape and refine skills in a group setting, the therapist will need to plan structured therapeutic activities. For example, a therapist may choose a fine motor game or plan a cooking activity allowing members to take turns. The sample schedule below highlights activities a therapist may complete with patients in a pediatric constraint induced movement therapy group.

9:00-9:30	**Yoga and schedule review**
9:30-10:00	**Donning art clothes**
10:00-10:30	**Craft**
10:30-11:00	**Toileting, washing hands, and snack**
11:00-11:30	**Gross motor and sensory activity**
11:30-12:00	**Game or fine motor activity**

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Author Bios

Erin Naber, PT, DPT is a Senior Physical Therapist in the Specialized Transition Program at Kennedy Krieger Institute in Baltimore, Maryland. She has made significant clinical, research and training contributions to the field of pediatric physical therapy. As a clinician, her areas of expertise are in constraint induced movement therapy and short-term intensive physical therapy for children with neuromotor impairments. She is currently a study team member on two approved research projects focused on clinical and patient-centered outcomes of these intensive therapy protocols.

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SCARLETT LAW GROUP

Scarlett Law Group is a premier California personal injury law firm that in two decades has become one of the state's go-to practices for large-scale personal injury and wrongful death cases, particularly those involving traumatic brain injuries.

With his experienced team of attorneys and support staff, founder Randall Scarlett has built a highly selective plaintiffs' firm that is dedicated to improving the quality of life of its injured clients. "I live to assist people who have sustained traumatic brain injury or other catastrophic harms," Scarlett says. "There is simply no greater calling than being able to work in a field where you can help people obtain the treatment they so desperately need."

To that end, Scarlett and his firm strive to achieve maximum recovery for their clients, while also providing them with the best medical experts available. "As a firm, we ensure that our clients receive both the litigation support they need and the cutting-edge medical treatments that can help them regain independence," Scarlett notes.

Scarlett's record-setting verdicts for clients with traumatic brain injuries include $10.6 million for a 31-year-old man, $49 million for a 23-year-old man, $26 million for a 7-year-old, and $22.8 million for a 52-year-old woman. In addition, his firm regularly obtains eight-figure verdicts for clients who have endured spinal cord injuries, automobile accidents, big rig trucking accidents, birth injuries, and wrongful death.

Most recently, Scarlett secured an $18.6 million consolidated case jury verdict in February 2014 on behalf of the family of a woman who died as a result of the negligence of a trucking company and the dangerous condition of a roadway in Monterey, Calif. The jury awarded $9.4 million to Scarlett's clients, which ranks as one of the highest wrongful death verdicts rendered in recent years in the Monterey County Superior Court.

"Having successfully tried and resolved cases for decades, we're prepared and willing to take cases to trial when offers of settlement are inadequate, and I think that's ultimately what sets us apart from many other personal injury law firms," observes Scarlett, who is a Diplomate of the American Board of Professional Liability Attorneys.

In 2015, Mr. Scarlett obtained a $13 million jury verdict for the family of a one year old baby who suffered permanent injuries when a North Carolina Hospital failed to diagnose and properly treat bacterial meningitis that left the child with severe neurological damage. Then, just a month later, Scarlett secured an $11 million settlement for a 28-year-old Iraq War veteran who was struck by a vehicle in a crosswalk, rendering her brain damaged.

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