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RESEARCH ARTICLE

The Pirate Group Intervention Protocol: Description and a Case Report of a Modified Constraint-induced Movement Therapy Combined with Bimanual Training for Young Children with Unilateral Spastic Cerebral Palsy

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Abstract

The purpose of this article was to describe a child-friendly modified constraint-induced movement therapy protocol that is combined with goal-directed task-specific bimanual training (mCIMT–BiT). This detailed description elucidates the approach and supports various research reports. This protocol is used in a Pirate play group setting and aims to extend bimanual skills in play and self-care activities for children with cerebral palsy and unilateral spastic paresis of the upper limb. To illustrate the content and course of treatment and its effect, a case report of a two-year-old boy is presented. After the eight-week mCIMT–BiT intervention, the child improved the capacity of his affected arm and hand in both quantitative and qualitative terms and his bimanual performance in daily life as assessed by the Assisting Hand Assessment, ABILHAND-Kids, Video Observations Aarts and Aarts Module Determine Developmental Disregard, Canadian Occupational Performance Measure and Goal Attainment Scaling. It is argued that improvement of affected upper-limb capacity in a test situation may be achieved and retained relatively easily, but it may take a lot more training to stabilize the results and automate motor control of the upper limb. Future studies with groups of children should elaborate on these intensity and generalization issues. Copyright © 2011 John Wiley & Sons, Ltd.

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Keywords

modified constraint-induced movement therapy (mCIMT); bimanual training (BiT); cerebral palsy (CP); Video Observations Aarts and Aarts (VOAA)

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Introduction

Children with unilateral cerebral palsy (CP) encounter many practical obstacles when using their hands in activities of daily life (Skold et al., 2004). Impaired hand

function is one of the most disabling symptoms in children with unilateral CP (Beckung and Hagberg, 2002), who use their affected hand with reduced frequency as well as with lower quality compared with the unaffected hand. Therapeutic interventions to increase

manual performance in children with unilateral spastic CP have changed over the last decade. Recent advances in neuroscience and clinical rehabilitation of upper extremity paresis provide the hope of developing more effective interventions (Garvey et al., 2007). Based on the current knowledge of the development and plasticity of the central nervous system, therapy should aim at preserving and potentiating the substrates for motor control in early life (Wittenberg, 2009). One of these therapies is constraint-induced movement therapy (CIMT) (Charles et al., 2001). In recent years, CIMT has been proposed as treatment for adults with hemiparesis (mainly due to stroke) and children with unilateral spastic CP. It aims to improve the use of the affected arm and hand in quantitative and qualitative terms (Charles and Gordon, 2005; Hoare et al., 2007a, b; Taub et al., 2007; Huang et al., 2009; Brady and Garcia, 2009; Aarts et al., 2010). One reason why individuals do not use their affected arm and hand relates to the fact that they have repeatedly experienced failure when using this hand (Eliasson et al., 2003). Two different but linked mechanisms incorporated in CIMT are considered to be responsible for increased use of the affected extremity: overcoming learned non-use and inducing use-dependent cortical reorganization (Morris and Taub, 2001). To overcome learned non-use and improve functioning of the affected upper limb, it has been suggested that the well-functioning extremity needs to be restrained. Developmental disregard as it is described in the paediatric literature on hemiparesis (Taub et al., 2004; Deluca et al., 2006; Hoare et al., 2007a, b) is comparable with the learned non-use phenomenon in adults who have sustained stroke. Developmental disregard evolves from the sensorimotor disorder as the affected arm does not receive sufficient practice and experience throughout childhood (Sutcliffe et al., 2009). In children, there may not be the potential to “unmask” motor function, as frequently described in adults. Therapy must therefore create the opportunity, experience and environment within which these children can learn how to use their affected limb (Eliasson et al., 2003). The improvements can result in functional recovery at the activity level of the International Classification of Functioning, Disability and Health (ICF) (World Health Organisation, 2010), which is defined as follows: successful task accomplishment using limbs or end effectors typically used by non-disabled individuals (Levin et al., 2009). In this context, an end

effector is defined as a body part such as the hand that interacts with an object or the environment (Levin et al., 2009). The experience of correctly using the affected arm and hand is purported to both reverse the behavioural aspects of the suppression of the affected limb's use and to reward this limb's use in even such simple tasks as the stabilization of an object (Hoare et al., 2007a, b). CIMT seems to be promising for children with hemiparetic CP (Gordon et al., 2006) and is proposed as a method to achieve this behavioural change (Deluca et al., 2006). In addition, the increased use of the affected hand is purported to induce cortical reorganization. In the first study to demonstrate cortical reorganization after a version of CIMT in a child with hemiplegia (Sutcliffe et al., 2007), functional magnetic resonance imaging (fMRI) showed increased contralateral activity (i.e. of the affected hemisphere) after therapy, with a shift in laterality from the ipsilateral to the contralateral hemisphere. That study reported both clinical improvement and cortical reorganization in an eight-year-old boy with congenital right hemiparetic CP who underwent modified CIMT for three weeks. In addition, in their fMRI study with 10 patients with congenital hemiparesis, Juenger et al. (2007) reported that even a short period of 12 days CIMT can induce changes of cortical activation in congenital hemiparesis. In their sample, increases in fMRI activation were consistently observed in the primary sensorimotor cortex of the affected hemisphere. Thus, they concluded that the potential for neuromodulation is preserved in the affected hemisphere after early brain lesions.

The approach to CIMT appears to diverge among authors and so do the names given to the interventions related to it. The most useful description was given by Taub et al. (2007).

- CIMT is the restraint of the unaffected upper limb combined with *more* than three hours of therapy per day for the affected limb (massed practice), which is provided for at least two consecutive weeks
- modified constraint-induced movement therapy (mCIMT) is the restraint of the unaffected upper limb with *less* than three hours of therapy per day for the affected limb
- “forced use” therapy is the restraint of the unaffected upper limb without additional treatment for the affected limb.

According to the literature, there is considerable variety in the currently proposed therapeutic (m)CIMT protocols for children (Charles and Gordon 2005; Hoare et al., 2007a, b; Huang et al., 2009; Brady and Garcia, 2009). The use of mCIMT programmes in young children with unilateral spastic CP (Eliasson et al., 2005; Naylor and Bower, 2005; Cope et al., 2008; Coker et al., 2009) differs from the conventional, highly intensive CIMT protocol (a targeted restraint of the less-impaired arm during 90% of the waking hours over a period of two to three weeks) (Morris et al., 2006; Taub et al., 2006a, b) in several ways and typically involves the following: a reduction in the hours per day wearing the constraint and a reduction in the hours of shaping per day, accompanied by an increase in the number of treatment days. Furthermore, alternative constraints have been offered such as a mitt, a splint or a sling, as well as a provision of therapy in the home environment, and embedding the therapy within the context of play (Brady and Garcia, 2009).

Despite these amendments to the CIMT protocol for young children, motor learning principles would suggest that improvement in using the two hands together will be maximized by repetitive practice of bimanual goal-directed tasks (Charles and Gordon, 2006; Boyd et al., 2010). Charles and Gordon argue that children with unilateral CP have impairments in bimanual coordination beyond their unilateral impairment (Charles and Gordon, 2006). Therefore, these authors developed The Hand Arm Bimanual Intensive Training (HABIT) with a focus on equal use of both hands in bimanual tasks (Charles and Gordon, 2006; Gordon et al., 2007). Bilateral or bimanual training has been investigated as a potential rehabilitation intervention although to a lesser extent than CIMT (Stoykov and Corcos, 2009). According to the current literature, possible underlying mechanisms important for bimanual training include recruitment of the ipsilateral corticospinal pathways, increased control from the contralateral hemisphere and normalization of inhibitory mechanisms (Stoykov and Corcos, 2009). McCombe, Waller and Whithall have argued that, even within a primarily unilateral training regimen, it is important to include bimanual training. They state that, in comparison with unilateral training, bilateral training is superior for training bimanual activities (McCombe and Whithall, 2008).

To achieve the best results in children with unilateral CP, we conclude from the aforementioned studies that

training should combine mCIMT and bimanual training (BiT) principles and must 1) be focused on children with unilateral spastic CP; 2) take place in a challenging environment; 3) be intensive and given in a relatively short period; 4) take place among peers; 5) focus on meaningful activities; 6) start with unimanual training feasible for young children (mCIMT); 7) end with goal-directed (Lowing et al., 2009a, b) task-specific (Hubbard et al., 2009) BiT to integrate the activated upper-limb functions in age-appropriate skills defined and prioritized by the parents; and 8) use motor learning strategies. The intention of this mCIMT–BiT intervention, based on dynamic systems theory,* is to promote motor learning by encouraging the child to actively explore and solve problems during the performance of complex goal-directed tasks in meaningful environments (Valvano, 2004; Levac et al., 2009). Consequently, we developed a mCIMT–BiT protocol within a pirate play theme (Aarts et al., 2010). The purpose of this manuscript is to provide a detailed description of the so-called “Pirate group” intervention protocol, its theoretical background and its rationale, in order to promote understanding of this approach and to enable future research. To illustrate the content and course of treatment and its effect, a case report of a two-year-old boy is presented.

General description and theoretical background

The Pirate group intervention is based on four components.

1. mCIMT combined with BiT

This mCIMT–BiT intervention consists of three main elements derived from Taub’s CIMT protocol (Mark and Taub, 2004; Taub et al., 2006a, b), which have been modified to create an eight-week programme of child-friendly therapy with a combination of unimanual and bimanual massed practice. These main elements include the following:

*Dynamic systems theory views movement as resulting from the interaction of many subsystems within the individual with features of the functional task to be accomplished and with the environmental context in which the movement takes place (Levac and DeMatteo, 2009).

- (1) Leaving the child no option but to use the impaired upper extremity during the mCIMT afternoons in the Pirate group as the non-affected upper extremity has been incapacitated by a sling and also by continuously eliciting and prompting the child to use the affected arm and hand (the so-called "Pirate hand")
- (2) Repetitive, task-specific training and shaping of the movements of the impaired upper extremity in unimanual (restraint of the non-affected arm during the first six weeks) and bimanual tasks (during the last two weeks), with the frequency and duration of training sessions modified to three hours per day, three days per week (Gordon et al., 2005; Morris et al., 2006). Five strategies recommended by Hubbard et al. were used to guide the task-specific training (Hubbard et al., 2009). To facilitate recall, Hubbard et al. have called them the five "Rs": i.e. task-specific training should be *relevant*, *randomly* ordered, *repetitive*, aim towards *reconstructing* the whole task and contain positive *reinforcement*
- (3) A "transfer package" of adherence-enhancing behavioural procedures designed to transfer the gains made during the training in the Pirate group to the child's home environment by using family-centred practice and working through dialogue with the caregivers using daily administration, a home diary, home exercises and intensive contact with the caregivers.

2. Motor learning theory and strategies

Although temporary improvements in motor performance during therapy are encouraging, the ultimate goal of interventions must be to promote motor learning, that is to achieve relatively permanent changes in motor skill capability that are transferred and generalized to new learning situations (Schmidt and Lee, 2005). Motor learning is commonly divided into explicit (i.e. learning component recall or recognition) and implicit learning (i.e. inadvertent, unconscious learning) (Subramanian et al., 2010). In order to practise the tasks during mCIMT, the child has to use the affected arm and hand to solve the problem of performance (implicit learning). The practical application of both explicit and implicit motor learning by the child, within the mCIMT-BiT intervention, is fostered by the therapist's use of motor learning strategies (Shumway-Cook and Woollacott, 2001; Larin 2006).

The therapists in this intervention: 1) give verbal instructions to provide the children with relevant task information or direct the child's attention to specific aspects of the task; 2) organize the structure, schedule and amount of physical practice; and 3) provide verbal feedback about task outcome and performance. Extrinsic feedback on outcome gives knowledge of results (Subramanian et al., 2010). This extrinsic feedback motivates the children in repetitive task practice. Knowledge of performance is extrinsic feedback about the movement pattern (Subramanian et al., 2010); in our intervention this kind of feedback addresses the quality of the use of the affected arm and hand (i.e. grasping with dorsal flexion of the wrist, the so-called "Pirate wrinkle"). Feedback about atypical movement patterns is important for children with unilateral spastic CP. Compensatory movements may help these children perform tasks in the short term, but in the long term they can lead to problems such as pain, discomfort and joint contractures (Vaz et al., 2006, 2008). In addition, permitting the child to use compensatory movements could lead to a pattern of learned non-use, limiting the capacity for subsequent gains in motor function of the paretic arm (Taub et al., 1993; Levin et al., 2009). Because parents support their child's practising at home, it is also important for them to understand that compensatory strategies may reflect a habitual response of the central nervous system, which has been developed because there was not sufficient motor control in the affected limb to perform the task more efficiently (Cirstea et al., 2003). Applying motor learning strategies to the training should improve functional recovery at the activity level: the tasks are to be performed using the same end effectors and joints in the same movement patterns typically used by non-disabled individuals (Levin et al., 2009).

3. The use of play in a group therapy context

A group approach is used because of the positive effects of children coming together for therapy, including healthy competition between peers (motivation) and behaviour modelling (Blundell et al., 2003; Crompton et al., 2007). Some tasks may not always be sufficiently challenging or meet the specific needs of all participants in group training. Crompton et al. (2007) concluded that relatively small group sizes and the presence of additional personal support facilitated each child's involvement in tasks at an appropriate

level. As play is the most meaningful occupation in a child's life (Knox and Maillou, 1997), it is the preferable context for therapeutic exercises. The pirate play theme was chosen because it frequently challenges the child to use the affected arm and hand (the pirate arm). By selecting activities that are both feasible to serve therapeutic goals and at the same time an attractive play experience for a child, it is possible to reach these goals through play (Knox and Maillou, 1997). Play is both the focus of this intervention and the medium through which the therapists intervene. An important aspect in this context is that a child is more likely to learn and retain information when it is intrinsically motivated (Okimoto et al., 2000). Intrinsic motivation refers to active involvement, showing good temper, maintaining tasks that involve various difficulties and barriers, repeating actions and activities and being interested and involved in the process of the task more than in the product (Okimoto et al., 2000). Csikszentmihalyi's (1997) concept of "flow" relates to the emotional qualities of these play experiences. The main aspect of this concept is a high level of arousal/alertness or increased concentration, focus and involvement with one's actions. The therapists in the Pirate group offer activities at a challenging level for each child and offer them in such a way that the children have fun and are eager to repeat the activities and get absorbed in the group play, thus reaching the flow state.

4. Parent involvement and homework programme

Paediatric occupational therapists strive to work according to family-centred service (FCS) principles. FCS is a philosophy and method of service delivery for children and parents that emphasizes a partnership between parents and service providers, focuses on the family's role in decision-making about the child and recognizes the parents as the experts for the child's status and needs (Rosenbaum et al., 1998). The conclusion in the study by Law et al. (2003) was that organizations with family-centred cultures have an important influence on outcomes: parents experienced the services as more family centred and were more satisfied with these services. In that study, they also found that family centeredness is linked to better outcomes for children. FCS prescribes an equal collaboration between the parents and the professional (Rosenbaum et al., 1998) and focuses on the child's occupations and the family's occupations. Any problem related to

care or self-care has an impact on family occupation, e.g. a child's problem with handling cutlery disturbs the family during dinner because the child needs extra help. To identify these problems in our study, the Canadian Occupational Performance Measure (COPM) (Law et al., 2005) is administered, and goals for mCIMT-BiT are formulated according to the occupational needs of the child that have been selected and prioritized by the parents. During intervention, intensive communication with parents is facilitated by a so-called "Pirate book" with descriptions of exercises to be practised at home and a home diary to register bimanual performance for targeted tasks and to report the daily observation of events. This diary is important for the transfer of newly learned skills to the home environment. For that reason, the child also receives individual materials to take home in order to practise those particular skills on the days when the Pirate group does not meet. Another way to involve parents in the mCIMT-BiT training is to let them observe their child during the Pirate group session through a one-way screen. By watching, parents learn useful approaches to encourage their child to use the affected arm and hand. To optimize the transfer after the intervention period, there are individual consultations with parents with suggestions for future training and ways to implement the new strategies at home.

Modified constraint-induced movement therapy-bimanual training in the Pirate group

The intervention takes eight weeks during which the participating children visit the out-patient rehabilitation unit of the Sint Maartenskliniek, Nijmegen, the Netherlands for three afternoon sessions per week, each lasting three hours. The main outcome of the intervention is on individual performance and participation in daily activities. This outcome is described in goals that are trained in the last two BiT weeks of the intervention and are determined by the parents and the therapists together. The mCIMT-BiT embedded in the Pirate group starts with a six-week period in which the "constraint" (mCIMT) is in effect and the functional impaired upper limb is forced to be used. To integrate the new skills into daily life activities, the constraint period is followed by a two-week period of bimanual, goal-directed, task-specific training (BiT). A Pirate group consists of six children who are guided

by four occupational therapists, one physical therapist and one therapy assistant. The rooms for the intervention are decorated as a pirate island with all kinds of pirate attributes. A strict timetable is repeated every afternoon (Appendix I).

During the mCIMT weeks of the intervention, the pirates are told that they have injured the non-affected arm during a pirate activity and, as a consequence, it needs to rest. During the constraint phase, the wounded arm in the sling is part of the pirate outfit. The sling is strapped to the child's trunk and, except the proximal end, is sewn shut to prevent the non-affected hand being used as an assist (Figure 1a and b). Fastening the sling to the trunk prevents bimanual use or any cheating that might occur if the sling were free or if a cast were worn (Gordon et al., 2005). In this way, the pirate is forced to learn (implicit learning) to do everything with the "non-wounded", affected arm and hand. This hand has to handle a sword, beat the drums, sweep the deck of the ship, cook for the other pirates, eat dinner with a fork, hold a drinking cup, carry and drag wooden blocks, and so forth (Figure 2). Repetitive task practice and shaping of the movements of the impaired upper extremity are performed in activities with targeted movements and graded constraints during both the

mCIMT and BiT. Feedback and instructions are given about performance and the result of execution of the task to enhance generalization of qualitatively good movement patterns to other activities and settings. As "transfer package", each child takes home a registration folder which lists all the activities to be performed at home with the affected hand (Appendix II).

Using the COPM, the parents and the therapists together determine the goals for the BiT following the CIMT weeks. The most important COPM goal is transcribed into steps using Goal Attainment Scaling (GAS) (Eliasson et al., 2005) to involve parents in the process of stepwise attaining goals. Examples of goals for BiT are age-appropriate play with dolls or construction materials, games using a ball, and climbing; for effective self-care, they include activities like dressing, spreading and cutting sandwiches, eating and drinking; (pre) school activities include tearing paper, cutting with scissors and pasting. The pirates also learn how to use both hands during age-related bimanual activities with the "Do it yourself box" as a part of repetitive bimanual task training structured by a story, for example "the pirate is very thirsty; he opens the bottle and fills the cup" (Figure 3). Furthermore, the children are instructed to dress themselves daily in the way that they

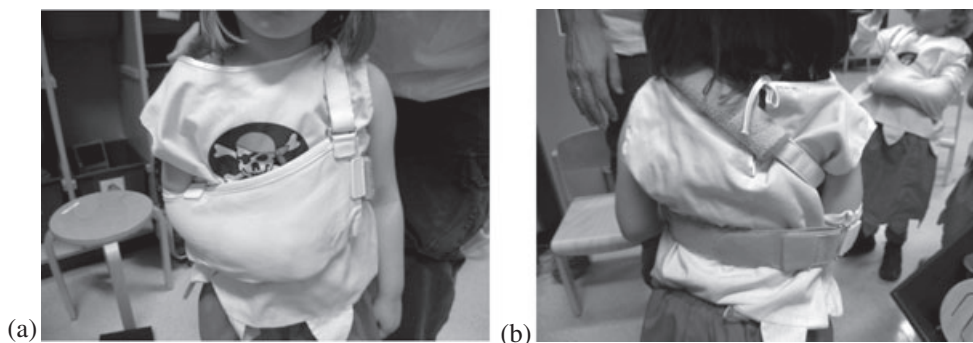


Figure 1 Girl (left side affected) in pirate dress with sling; (a) front side, (b) back side



Figure 2 Boy (Simon) during mCIMT in the Pirate group



Figure 3 Boy (Simon) during BiT in the Pirate group

had been taught with their own clothes, to eat, drink and play with their own toys, and to cut and paste at home and at school in “the pirate way”. During the “Pirate show”, on the last day of the mCIMT–BiT intervention, the children present their achievements to all the parents and show them all the “Pirate skills” (based on the selected goals in the COPM) they have mastered based on the selected goals in the COPM. This special performance on the last afternoon culminates in a pirate diploma for each child. A DVD film of the gains in unimanual and bimanual ability made during the eight weeks in the Pirate group is handed out to show and instruct significant others (teachers, grandparents etc.) and to promote maintenance of effects.

To illustrate the content and course of the Pirate play group intervention protocol (see Appendix I) and its effects in quantitative and qualitative terms, we present a case study.

Case report

Participant

Simon (fictive name) is a boy with unilateral spastic CP (left body side affected; aged 2.7 years; Gross Motor Function Classification System (Palisano et al., 1997) I and Manual Ability Classification System). In the case of Simon, the occupational issues were as follows: inability to play with sand and bucket on the beach, inability to dress and undress, inability to hold a ball long enough to throw or roll it. These issues are related to the inability to perform bimanual activities that require fine motor control or strength. Simon rarely used his affected arm, that is, he only used it when necessary and always after a delay. He generally used his affected hand with his wrist in palmar flexion but had the ability to actively extend his wrist (125°). Increased tone interfered with performing bimanual tasks whenever elbow extension, forearm supination or thumb abduction on the affected side was stimulated.

Intervention

During mCIMT, the main focus for Simon was on promoting more frequent use and improving the quality of movements of his affected left arm. Reaching, grasping, holding and releasing were elicited in various pirate play activities that fitted his interests. These activities consisted of the following:

- Games that required sufficient repetition of these basic motor behaviours, appealed to Simon’s motivation, and were part of a pirate’s play (e.g. dropping balls into a tube).
- Stimulation of forearm supination and wrist extension, which was extensively trained in games such as Memory and Lotto and while dancing to music.

At home, he performed the activities listed in his home registration folder under his parents’ supervision (Appendix II). He also applied newly learned pirate tricks at home, such as eating his sandwich with his pirate hand and playing with one of the games from the Pirate group that he was allowed to take home.

During BiT, the goal-directed training for Simon consisted of the following (see Appendix III, COPM and GAS):

- COPM goal 1: learning how to make big cakes and castles with sand and to look for pirate treasures by holding a shovel with both hands to dig into the sand was practised in the sandbox of the Pirate group and at home.
- COPM goal 2: holding on to objects with both hands while drinking from a cup, eating with fork and knife, peeling his own banana and opening a package of cookies was practised every session.
- COPM goal 3: dressing and undressing were practised in various ways and different situations, e.g. changing in and out of his pirate costume at the

- beginning and at the end of each session; donning and doffing his own pyjamas in the correct way at home.
- COPM goal 4: holding a ball long enough to throw or roll it over was practised individually and in the Pirate group.
 - “Do it yourself box”: depicting a pirate story with the use of a story based on the contents in the “Do it yourself box” was rehearsed every day at home; all the strategies that had been learned during the previous six weeks of mCIMT were repeated with emphasis on bimanual daily life activities.

Outcome measure

To assess treatment effects, several outcome measures were selected at the level of body functions, activities and participation, activities and body functions of the ICF (World Health Organisation, 2010). Body function measures were the active and passive Range of Motion (aROM and pROM) of wrist and elbow extension (Stuberger et al., 1988). Activity measures were the Assisting Hand Assessment (AHA) (Krumlinde-Sundholm et al., 2007), ABILHAND-Kids (a measure of manual ability for children with upper limb impairments)

(Arnould et al., 2004), the Melbourne Assessment of Unilateral Upper Limb Function (Melbourne) (Randall, 1999), and the Video Observations Aarts and Aarts (VOAA) module Determine Developmental Disregard (Aarts et al., 2009). Participation measures were the COPM (Law et al., 2005) Performance (COPM-P) and Satisfaction (COPM-S) scores as well as the GAS (Eliasson et al., 2005).

Results

Table 1 presents the results of the outcome measures at the level of participation, activities and body functions at baseline (week 0), post-treatment (week 9) and at follow up (17 weeks). His mother was very satisfied (COPM-S) with his improved performance (COPM-P) during bimanual activities. He succeeded in reaching his GAS goal: his performance of the activity “shovelling” at baseline and after the intervention are illustrated in Figure 4a and b. Simon had learned to turn over a pail filled with sand.

By the end of the intervention, Simon could put on and take off his own loosely fitting sweater and pants by himself. He had learned to roll and throw the ball

Table 1. Simon's scores on outcome measures for body functions, activities and participation

Outcome measures	T1	T2	T3
aROM wrist (extension in °)	125	130	125
pROM wrist (extension in °)	180	180	180
aROM elbow (extension in °)	175	170	175
pROM elbow (extension in °)	175	180	180
AHA (% score)	44	59	56
AHA (logits score)	-0.71	1.66	1.20
ABILHAND-Kids (raw score)	13	18	19
ABILHAND-Kids (logits score)	-1.38	-0.50	-0.33
Melbourne (% score)	61	63	61
VOAA-Capacity score (%)	33	78	56
VOAA-Performance Score (%)	62	76	86
VOAA-Duration Beads score (%)	56	63	61
VOAA-Duration Muffin score (%)	32	38	35
VOAA Developmental Disregard (%)	24	25	26
COPM-P	2	6.8	6.4
COPM-S	1	7	7
GAS	-2	+1	0

T1, baseline assessment (week 0); T2, post-intervention assessment (week 9); T3, follow up assessment (week 17); aROM, active range of motion; pROM, passive range of motion; AHA, Assisting Hand Assessment; Melbourne, Melbourne Assessment of Unilateral Upper Limb Function; VOAA, Video Observations Aarts and Aarts; COPM-P, Canadian Occupational Performance Measure-Performance score; COPM-S, Canadian Occupational Performance Measure-Satisfaction score; GAS, Goal Attainment Scaling (a score of -3 indicates a level lower than the initial performance level, -2 indicates an unchanged level of performance, -1 indicates a level lower than the desired outcome, 0 indicates that the desired outcome level has been achieved, +1 indicates somewhat more improvement than expected, and +2 indicates much more improvement than expected)



Figure 4 (a) Simon in the first week of the intervention holding a shovel with only one hand, not able to dig into the sand. (b) Simon on the last day of the intervention, holding a shovel with both hands to dig into the sand. He had learned to turn over a pail filled with sand

(known as a canon ball) like a real pirate. He had learned to throw it into a basket and to knock over bowling pins with the ball as well.

After the intervention, Simon reached for objects using more normal movement patterns. His movements were also faster. He showed improvement in the quality of grasping, holding and releasing, and he had increased the frequency of these behaviours during bimanual tasks (VOAA). He was more effective with his assisting hand (AHA) and also more able to perform bimanual tasks (ABILHAND-Kids), although the Melbourne did not show improvement of unimanual capacity of his affected arm and hand. The aROM and pROM of wrist and elbow extension had not changed either. For tasks that did not demand the use of his affected hand, he continued to use only his unaffected hand, thus still showing signs of developmental disregard (VOAA).

Discussion and conclusion

The outcome measures in the case report presented in this paper were selected to assess the effects of mCIMT-BiT at all levels of the WHO's (World Health Organisation, 2010) ICF. Particularly those measures were chosen that would provide family-centred information on functional change because that information would be meaningful to both the children and their

families. Because the main focus of the six weeks of mCIMT was to improve the quantitative and qualitative use of the affected arm and hand, assessment at the activity level of the ICF was considered most relevant. In this perspective, it is interesting to note that improvement of affected upper-limb capacity in a test situation may be achieved relatively easily based on "unmasking" existing sensorimotor functions, and this improvement can easily be retained. It may, however, take a lot more training to stabilize the results. A possible explanation for the observed discrepancy between "frequency" and "duration" of spontaneous use of the affected arm and hand may be the fact that motor control of the upper limb is insufficiently automated. Automatization processes generally require vast amounts of training and practice, such as when learning to play an instrument or perform sports. Based on experiences and intuitive notions from the Pirate group intervention, intensive and focused training interventions longer than eight weeks may not be feasible, especially in young children. An alternative to prolongation of the Pirate group program may be to use booster sessions of mCIMT-BiT during the child's development. Preliminary experiences with such booster sessions are good. In addition, intensifying the transfer package carried out by parents may be an alternative option to optimize the child's insight in and responsibility for his/her daily use of the affected arm and hand. Future

studies should elaborate on these intensity and generalization issues.

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Supporting Information

Supporting information may be found in the online version of this article:

Appendix I. Pirate group programme: modified Constraint-Induced Movement Therapy (mCIMT; weeks 1–6) and Bimanual Training (BiT; weeks 7–8).

Appendix II. Home registration form.

Appendix III. Simon's Canadian Occupational Performance Measure (COPM) and Goal Attainment Scaling (GAS).

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