The Children's Trust
For children with brain injury

Evidence informed upper limb assessment and management guidelines

Contents

How to use these guidelines

The upper limb pathway is applicable to all children who present with upper limb difficulties. The assessment decision tree will help you decide which upper limb assessment(s) to complete. The management matrix gives an overview of treatments appropriate for children with different levels of upper limb ability, to help inform clinical reasoning and decision making. The evidence based summaries that follow provide more information regarding the different interventions, including, where available, evidence for efficacy, appropriate dosage and treatment protocols.

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Upper limb assessment decision tree

All children: PEDI/FIM+FAM and GAS light

- Does the child present as a MACS I with no concerns with tone or range or movement
  - Yes → Complete Movement ABC, AMPS or school AMPS or Bayleys (if under 3)
  - No → Complete the CPUPS assessment
- Does the child have dystonia?
  - Yes → Complete Barry Albright dystonia scale
  - No → Does the child have a primarily unilateral impairment?
    - Yes → Does the child have purposeful active movement in at least their shoulder, elbow and/or wrist on command (can be gross patterns)? And, can they follow instructions or engage in a self-directed play based activity
      - No → Use goal attainment scaling and/or COPM
      - Yes → Is the child over 18 months?
        - No → Use goal attainment scaling and/or COPM
        - Yes → Use the Assisted Hand Assessment
          - Is the child aged over 5 years?
            - Yes → Use the Melbourne assessment of unilateral upper limb function
    - No → Use goal attainment scaling and/or COPM

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Upper limb management matrix

	CONSTRAINT	BI-MANUAL	FES	STATIC SPLINTING	DYNAMIC SPLINTING	GOAL DIRECTED TRAINING	HANDWRITING
MACS I-II	If unilateral involvement: Consider use for extensive periods during the day in normal activities of daily living. Should also be periods of bimanual use. Consider a targeted CIMT task programme that is challenging but achievable. Intensity is necessary.	Consider an intensive programme which includes a range of functional activities related to the child's goals. Train parents/staff to include the upper limb in all ADL.	Consider use if specific muscles are impairing functional performance.	Assess need for splint on individual basis, with goal of splint use clear and documented. Consider use for maintaining range of movement or reduction of pain in selected cases. Review regularly. Splinting or casting should be used following Botulinum Toxin	Not appropriate	Consider use of graded goal directed training that is challenging and addresses goals in context.	Consider practicing handwriting in context – work on speed, neatness, fluidity, legibility, and spacing. Consider additional exploration of alternative methods of documentation
MACS III due to bilateral upper limb involvement	Not appropriate	Consider an intensive programme of bimanual training that includes a range of functional activities related to the child's goals. Tasks will need to be adapted. Train parents/staff to include the upper limb in all ADL.	Consider use alongside task based training if reduced voluntary muscle action in specific muscle groups is limiting function.	Assess need for splint on individual basis, with goal of splint use clear and documented. Consider use for maintaining range of movement or reduction of pain in selected cases. Review regularly. Splinting or casting should be used following Botulinum Toxin	Consider use alongside task based training if clear reasoning and goals noted.	Consider goal directed training, with adaptations to enable completion of the goals based activity.	Consider additional exploration of alternative methods of documentation Practice handwriting in context Work on letter formation, pencil control, fine motor skills in activities

	CONSTRAINT	BI-MANUAL	FES	STATIC SPLINTING	DYNAMIC SPLINTING	GOAL DIRECTED TRAINING	HANDWRITING
MACS III due to severe hemiplegia affecting the non-dominant limb	Consider targeted CIMT exercise programme only if the child has sufficient voluntary motor control in their affected upper limb to complete 30 minutes of activities. Activity analyse to find available tasks	Consider intensive bilateral training where the affected upper limb acts in a supporting role.	Consider use alongside task training if the child has some voluntary muscle control	Assess need for splint on individual basis, with goal of splint use clear and documented. Consider use for maintaining range of movement or reduction of pain in selected cases. Review regularly. Splinting or casting should be used following Botulinum Toxin	Consider use alongside task based training if clear reasoning and goals identified	Consider goal directed training, with adaptations to enable completion of the goals based activity.	Not required
MACS IV due to bilateral involvement	Not appropriate	Consider an intensive bilateral training programmes with tasks selected to be challenging but achieveable. Look at facilitating training within everyday life	Unlikely to be appropriate.	Assess need for splint on individual basis, with goal of splint use clear and documented. Consider use for maintaining range of movement or reduction of pain in selected cases. Review regularly. Splinting or casting should be used following Botulinum Toxin	Consider use alongside task based training if clear reasoning and goals identified	Consider use of goal directed training alongside environmental adaptations to allow completion of goals in context.	Explore alternative methods of recording information

	CONSTRAINT	BI-MANUAL	FES	STATIC SPLINTING	DYNAMIC SPLINTING	GOAL DIRECTED TRAINING	HANDWRITING
MACS IV due to severe hemiplegia affecting the dominant arm	Consider using for specific tasks at specific times Activity analysis to find options for available function	Consider using an intensive programme where the affected arm is the supporting arm. Use within the child's everyday life, with tasks adapted to be achievable. Teach child/family/support staff to prompt the use within everyday life	Consider use alongside task based training to maximise effects if the child has some voluntary movement	Assess need for splint on individual basis, with goal of splint use clear and documented. Consider use for maintaining range of movement or reduction of pain in selected cases. Review regularly. Splinting or casting should be used following Botulinum Toxin	Consider use alongside task based training if clear reasoning and goals noted.	Consider use of goal directed training alongside environmental adaptations to allow completion of goals in context.	Train non-dominant hand Explore alternative methods of recording information if necessary
MACS V	Not appropriate	Not appropriate	Not appropriate	Assess need for splint on individual basis, with goal of splint use clear and documented. Consider use for maintaining range of movement or reduction of pain in selected cases. Review regularly. Splinting or casting should be used following Botulinum Toxin	Not appropriate	Adapt environment to allow child to use any purposeful movement in goal directed activities.	Explore alternative methods of recording information

	STRENGTHENING	SPASTICITY MANAGEMENT (If spasticity present)	NEURO-DEVELOPMENTAL THERAPY/BOBATH	MIRROR BOX	VIRTUAL REALITY	JOINT PROTECTION AND SUPPORT
MACS I-II	Consider completing progressive resisted strength training if muscle weakness is identified	Liaise with Drs re medication Refer to botox team for assessment Consider splinting and strengthening programme post botox.	Consider modern Bobath principles alongside CIMT/BiMT.	Not appropriate	Consider use of virtual reality alongside other rehabilitation interventions. Aim for intensity- ie 45 minutes a day. Commerically available or specialist equi0pment may be of use depending on child's needs, goals and likes.	Not appropriate
MACS III due to bilateral involvement	Consider completing progressive resisted strength training if muscle weakness is identified	Liaise with Drs re medication Refer to botox team for assessment Use splinting and strengthening programme post botox	Consider modern Bobath principles alongside CIMT/BiMT	Not appropriate	Consider use of virtual reality alongside other rehabilitation interventions. Aim for intensity- ie 45 minutes a day. Specialist technology likely to be needed to meet child's needs and allow successful use.	Consider positioning to encourage function and attention

	STRENGTHENING	SPASTICITY MANAGEMENT (If spasticity present)	NEURO-DEVELOPMENTAL THERAPY/BOBATH	MIRROR BOX	VIRTUAL REALITY	JOINT PROTECTION AND SUPPORT
MACS IV due to bilateral involvement	Consider progressive strength training with gravity as the weight.	Liaise with Drs re medication Refer to botox team for assessment Consider splinting and strengthening programme post botox	Consider modern Bobath principles alongside CIMT/BiMT	Not appropriate	Consider use of virtual reality alongside other rehabilitation interventions. Aim for intensity- ie 45 minutes a day. Specialist technology likely to be needed to meet child's needs and allow successful use.	Consider position to encourage function and attention. Educate child, family and staff about careful handling of shoulder. Consider use of taping if hypotonia and shoulder subluxation present. Consider use of sling for transfers/mobility as short term option only if arm is painful or obstructing mobility.
MACS IV due to severe hemiplegia affecting the dominant limb	Consider use of electrical stimulation as method of strengthening until the child can move against gravity	Liaise with Drs re medication Refer to botox team for assessment Consider splinting and strengthening programme post	Consider using modern Bobath approach in working towards specific function based goals. Review regularly.	Consider mirror therapy as an adjunct to other therapies in children with high cognitive and receptive communication abilities, especially if a significant level of neglect.	Consider use of virtual reality alongside other rehabilitation interventions. Aim for intensity- ie 45 minutes a day. Specialist technology likely to be needed to meet child's needs and allow successful use.	Consider position to encourage function and attention. Educate child, family and staff about careful handling of shoulder. Consider use of taping if hypotonia and shoulder subluxation present. Consider use of sling for transfers/mobility as short term option only if arm is painful or obstructing mobility.

	STRENGTHENING	SPASTICITY MANAGEMENT (If spasticity present)	NEURO-DEVELOPMENTAL THERAPY/BOBATH	MIRROR BOX	VIRTUAL REALITY	JOINT PROTECTION AND SUPPORT
MACS V	Not appropriate	Liaise with Drs re medication Refer to botox team for assessment Consider splinting and strengthening programme post	Consider using modern Bobath approach in working towards specific function based goals. Review regularly.	Not appropriate	Specialist virtual reality may be of benefit if the child has some active volitional movement. Aim for intensity- ie 45 minutes a day.	Position to encourage function and attention. Educate child, family and staff about careful handling of shoulder. Consider use of taping if hypotonia and shoulder subluxation present. Consider use of sling for transfers/mobility as short term option only if arm is painful or obstructing mobility.

Constraint induced movement therapy at The Children's Trust
Evidence based summary-November 2017

Rationale

Constraint Induced movement therapy (CIMT) aims to increase upper limb function in children who have unilateral upper limb impairments. It involves restraining the unaffected upper limb to force the use of the affected limb during intensive task practice {Cimolin, 2012}. It is commonly used in rehabilitation for adults who have had strokes, and children with cerebral palsy. CIMT consists of casts worn on the affected limb, with 6 hours of therapy a day. Modified CIMT (mCIMT) involves protocols where the method of constraint and/or dose of intervention are changed.

Clinical question –

Should modified constraint induced movement therapy be offered to children with reduced upper limb functioning following acquired brain injuries (ABI) during residential rehabilitation?

Assessment

- All children should have an upper limb assessment based on the CPUPS (Scandinavian version of Cerebral Palsy Integrated Pathway) assessment
- Either the Melbourne Assessment of Unilateral Upper Limb Activity (MA2) or the Assisted Hand Assessment (AHA) should be used as part of the assessment depending on their age
- Children should also be classified according to their Manual Ability Classification System (MACS) level as a functional classification.
- Child and families goals and priorities relating the upper limb also need to be established
- Children need to have sufficient movement in their upper limb, and cognitive abilities, to engage in half an hour of unilateral upper limb activity.

Intervention

- Restrain the unaffected upper limb using a mitt.
- Engage the child in upper limb activities that are motivating, challenging, but achievable. These can include use of technology (iPAD, Timocco, Nintendo Wii), arts and crafts and/or games and tasks such as Connect 4, building blocks, Jenga,
- Aim for as a high a dose as possible (number of hours wearing the mitt), through completing sessions with qualified therapy staff, therapy assistants and nursing and care staff.
- Ensure that the child engages in bimanual training activities either alongside, or after, the mCIMT.

Summary of the evidence

<u>*Children with ABI*</u>

- Statistically significant changes in upper limb impairment, function and participation were shown in a group of 20 children who underwent a 2 week programme of mCIMT with 4 hours of therapy a day. All children had functional movement at shoulder and elbow, and sufficient cognitive and behavioural ability to engage in programme. On an individual basis 65% of children improved in AHA, and 80% in at least one Canadian Occupational Performance Measure (COPM) goal {Komar, 2016 #253}
- Statistically significant changes in upper limb impairment, function and on goals were seen in children with ABI who underwent a 23 day programme of CIMT of either 6 hours a day or 3 hours a

day of therapy (dependent on age and ability to participate). Children had all been discharged home, although it is unclear how far post injury they were {Reidy, 2012 #255}
- Children with brain tumours and resultant hemiplegia also showed improvements in function with a 3 week mCIMT programme {Sparrow, 2017 #260}
- Other case studies and pilot studies that have investigated mCIMT protocols involving between 2 and 4 hours of therapy a day have also shown benefits (Dickerson and Brown, 2007; Karmen et al. 2003; Gordon et al. 2007).

Children with CP

- A systematic review showed mCIMT improves upper limb function in children with hemiplegia who have CP {Chen, 2014 #259}.
- Benefits include increased use of affected limb in bimanual activities (Sakzewski et al., 2013), and improvement in children's goals and measures of occupational performance (Charles et al. 2006; Eliasson et al. 2013; Reidy et al. 2010)
- Children with severe upper limb impairments, and less than the recommended 20^{o} of active wrist extension (Brady and Garcia, 2009) can show benefits (Eliasson et al. 2013)
- Systematic reviews indicate that mCIMT improves upper limb impairment and function more than no treatment, but is no more effective than treatment without constraint {Chiu, 2016 #170}{Tervahauta, 2017 #258}

Guidance derived from clinical experience at TCT

Clinician's note that mCIMT can be well tolerated, especially if the child is able to understand the reasoning behind its use. Activities need to be carefully chosen and monitored by the treating therapist to ensure they are set at the right level for the child. Younger children, and/or those with cognitive difficulties require close supervision and may require physical prompts to ensure they use their affected upper limb.

Child and family experiences

Children and families have found the intervention beneficial, and have enjoyed the structured activities that were set for them. They have reported that it is tiring, especially when done at lunchtimes or in the evenings.

Clinical recommendation at The Children's Trust

Assess child/young person's upper limb function on admission using standardized measures where possible

Explore child and family preference of rehabilitation interventions

Consider use of mCIMT for children who have some a unilateral impairment, but have functional use of their affected upper limb, and the ability to engage in half an hour of activities.

Explore methods of increasing dosage of intervention through providing mCIMT within therapy sessions, and programmes set for it to be done outside of sessions.

Monitor outcomes and collect data to further develop knowledge in this field.

Upper limb bimanual therapy at The Children's Trust
Evidence based summary-November 2017

Rationale

Bimanual upper limb training encourages the use of the affected hand within bimanual tasks (Charles and Gordon, 2006). There is a well-established evidence base for the use of intensive bimanual therapy for children with cerebral palsy (Tervahauta, Girolami et al. 2017), yet in adults who have had strokes the evidence suggests it is inferior to unilateral upper limb training (Hatem, Saussez et al. 2016).

Clinical question –

Should bimanual upper limb training be offered to children with acquired brain injuries (ABI) during residential rehabilitation?

Assessment

- All children should have an upper limb assessment based on the CPUPS (Scandinavian version of Cerebral Palsy Integrated Pathway) assessment
- Either the Melbourne Assessment of Unilateral Upper Limb Activity or the Assisted Hand Assessment should be used as part of the assessment
- Children should also be classified according to their MACS level as a functional classification.
- Child and families goals and priorities relating the upper limb also need to be established

Intervention

- Activities should be functional and goal directed
- Activities need to be adapted to be achievable for the child
- Activities should be motivational for the child
- It is likely that high doses are needed to ensure children gain maximum benefit

Summary of the evidence

Children with ABI

- Children who were at least two years after ABI were included in a study by (Deppe, Thuemmler et al. 2013), alongside children with CP, to investigate modified constraint induced therapy (mCIMT) as compared to bimanual training. They found that both interventions produced similar changes in spontaneous upper limb use, but that mCIMT improved unilateral upper limb function more.

Children with CP

- Bimanual training is better than no treatment or very basic treatment, at improving hand and arm function (Novak, Mcintyre et al. 2013, Sakzewski, Ziviani et al. 2013).
- The evidence is insufficient to determine whether bimanual or mCIMT is more effective at improving unimanual or bimanual hand and arm function, participation in daily activities and achievement of individualised goals (Sakzewski, Ziviani et al. 2013, Tervahauta, Girolami et al. 2017)
- Bimanual training causes less frustration than mCIMT in children (Cohen-Holzer, Katz-Leurer et al. 2017)
- Bimanual training has typically be offered in intensive packages (6 hours a day for 10 days). A lower dose (30 hours) has resulted in clinically meaningful results, but these are not as great as those offered at a higher does (Sakzewski, Provan et al. 2015)

Adults who have had strokes

- Within the adult stroke literature bimanual training has involved non- functional upper limb movements, where the affected limb is either moved simultaneously to, or opposite to the unaffected limb. Evidence suggests that this does not improve upper limb impairments or disabilities (Hatem, Saussez et al. 2016)

- There is evidence that task specific training can improve upper limb function in adults post stroke (Foley et al. 2016).
- Higher doses of task specific upper limb training do not necessarily lead to better outcomes (Lang, Strube et al. 2016, Winstein, Wolf et al. 2016). This has looked at the number of repetitions of movements offered within an hour of therapy time 4 days a week, over 8 weeks and an extra 30 hours of therapy over 10 weeks (Winstein, Wolf et al. 2016)

Guidance derived from clinical experience at TCT

Bimanual training can be incorporated into the child's rehabilitation programme, but achieving sufficient dosage can be challenging giving the demands on the child. Incorporating bimanual training into their day to day lives can help increase dosage provided outside of therapy sessions.

Child and family experiences

Children and families experience of bimanual training tends to vary depending on their level of upper limb impairment, cognitive abilities and their motivation for improving their arm. For those that have some functional activity, and the ability and attention to participate in bimanual arm activities it has been successful and productive.

Clinical recommendation at The Children's Trust

Assess child/young person's upper limb function on admission using standardized measures where possible

Explore child and family preference of rehabilitation interventions

Consider use of bimanual, functional, goal directed training as part of the child's rehabilitation programme

Explore methods of increasing dosage of intervention through use in daily activities, and motivating activities to do on house. Ensure the child, family and nursing staff understand the child's level of ability and how to adapt tasks to be challenging yet successful.

Monitor outcomes and collect data to further develop knowledge in this field.

Upper limb NMES as a therapeutic adjunct at The Children's Trust
Best practice recommendations
July 2016

Rationale

Neuromuscular electrical stimulation (NMES) is an established treatment technique in neurological rehabilitation. Functional electrical stimulation (FES) is a form of NMES that stimulates muscles in functional patterns. It can be used to increase strength and range of movement, and aid motor relearning. There is strong evidence supporting its use in adults who have sustained strokes, and an emerging evidence base for its use in children with Cerebral Palsy. Early pilot studies indicate that it is of benefit to children with ABI.

> *Clinical question –*
> Should NMES be offered as part of the upper limb therapy rehabilitation programme at The Children's Trust?

Assessment

Children should be assigned a Manual Abilities Classification Level (MACS) (REF) prior to completing FES. A relevant outcome measure should be selected to measure the effectiveness of the intervention. The most appropriate standardised measures available are the Assisted Hand Assessment (AHA) or The Melbourne Assessment of Unilateral Upper Limb Activity (MA2).

The AHA is a measure of how well the child uses their affected hand spontaneously during play, whereas the MA2 measures what the child can do with their affected upper limb during specifically designated activities. The AHA is only valid in children up to the age of 12 years. Both of these measures would provide useful information regarding the effectiveness of NMES on the child's upper limb functioning, and the decision as to which measure should be based on the clinical reasoning, availability and the child's age.

The MA2 and AHA have been developed for children with any neurological deficits affecting their upper limb (Randall, Johnson and Reddihough 1999: Krumlinde-Sundholm & Eliasson 2003). However, most of the studies investigating the psychometric properties have been conducted with children with cerebral palsy (CP). Nonetheless, given that children with CP and children with ABI display similarities in their physical presentation (Bosques et al. 2016) it is appropriate to consider the evidence for this population. The MA2 has been shown to be the most reliable and valid of all the measures of upper limb activity for children with CP (Gerber, Labruyere and van Hedel (2016)). The AHA has demonstrated good reliability, validity and sensitivity to change in this population (Krumlinde-Sundholm et al., 2007; Holmefur et al.,2007).

Intervention

All contraindications/precautions should be checked prior to the intervention (Found at front of manual), and consent from child and parents gained. The Ottobock stiwell NMES machine has a variety of settings. The most useful are the individual programmes or the set FES programmes. Individual programmes will allow you to set the exact parameters wanted, and the FES are pre-programmed into functional programmes.

Assessment of the child's upper limb function will determine the correct programme. If the child has a specific deficit, target this muscle group/s using the individual programmes. There is no evidence regarding the best parameters for the stimulation, so use the ones pre-programmed into the machine to begin with. The timing of the contractions can then be adjusted to suit the child, and the rise/fall time adjusted if there are difficulties with tolerance.

A study has suggested that there is no difference between cyclic or patient triggered stimulation (de Kroon and Ijzerman 2008). Hypothetically, the cognitive engagement of patient triggering will assist with motor learning (Hubbard et al, 2013), however, this effort may also increase tone and impact upon function (Knutson and Chae 2015). Therefore, this should be assessed on a case by case basis.

The child should be engaged in task training during stimulation (Howlett et al, 2015) to maximise the benefits gained. Half an hour a day, 5 days a week has been shown to produce benefits in a child with ABI (Kelly, 2016) and adults who have had a stroke (Hsu et al. 2010). Outcomes should be reassessed after four weeks to ensure the intervention is effective for the child.

Summary of the evidence

Children with ABI

- *Pilot study using FES in children at least a year post stroke showed that it improved upper limb activity and function (Kapadia et al, 2012)*
- *Single case experimental design in a child in the subacute stages post stroke demonstrated that FES improved upper limb activity (Kelly, 2016)*

Children with CP

- *Randomised controlled trial (RCT) showed that NMES plus constraint induced movement therapy was significantly better at improving upper limb functional outcomes than CIMT alone (Xu et al, 2015)*
- *Literature reviews consisting of case controlled trials and single case studies concluded that FES is of benefit to improve upper limb function in children with CP (Bosques et al, 2016; Wright et al, 2012)*

Adults who have had strokes

- *NMES is of benefit in improving upper limb function in adults who have had strokes (Farmer et al, 2014)*
- *FES with task training has a significant treatment effect (Howlett et al, 2015)*
- *NMES that is either cyclically triggered or patient triggered produces changes at an impairment and function level (Nasciemento et al, 2014)*
- *FES did not improve upper limb function when used on the shoulder (Vadafar et al, 2014)*
- *NMES improved spasticity and range of movement, but not in the wrist (Stein et al, 2015)*
- *No specific investigations regarding parameters required, but 4 week interventions of 30 minutes a day have produced changes in upper limb activity (Hsu et al. 2010).*
- *No difference in cyclic versus patient triggered stimulation (deKroon et al.2008).*

Theoretical evidence

- *Triggering of the NMES by the patient will improve outcomes over cyclic triggering, due to the need for cognitive engagement, which is important in motor learning (Hubbard et al, 2013).*
- *Using task training alongside the stimulation will produce the greatest benefits, due to the need for repetitive task practice to induce neuroplasticity (Teasell and Hussain, 2013)*
- *Children who have no volitional upper limb movement are unlikely to change with the intervention (Foley et al, 2013).*

Guidance derived from clinical experience at TCT

Use of NMES has been beneficial for children with upper limb deficits following an ABI. Children who present between a MACS level of III and V, but with some intentional upper limb activity, have shown positive improvements with daily NMES over a 4 week period. Children who have no volitional upper limb control have not benefitted from the intervention. Some children have been unable to tolerate the intervention due to the sensation of the stimulation.

Summary

There is little research evidence supporting the use of NMES in the paediatric ABI evidence. However, clinical experience, theoretical evidence and research evidence from patient groups with similiar physical presentations do support its use.

Clinical recommendation at The Children's Trust

Assess child/young person's upper limb function on admission using standardized measures where possible
Explore child and family preference of rehabilitation interventions
Consider 30 minutes of individually tailored NMES, in combination with repetitive task training daily for four weeks for children who present between a MACS III and V.
Document outcomes and collect data to help build the evidence in this field
Monitor outcomes closely if the intervention is offered to children with no volitional upper limb movement.

Upper Limb Static Splinting at The Children's Trust
Best practice recommendations
August 2015

Rationale

Static splinting is a treatment approach used with adults and children to maintain range of movement following an acquired brain injury. It involves use of a ready- made or custom-made splint to position a joint or joints in a preferred position than the position at rest. The hypothesis is that provision of a prolonged, low-load stretch will help to maintain the length of muscle fibres in the muscles affected by the splint.

Clinical question – Is static splinting an effective intervention to help maintain upper limb range of movement in children following an acquired brain injury?

Implications

Assessment of baseline tone and range of movement

- Measurement of passive range of movement using goniometer or Biometrics (use guidelines).
- Oddstock tracing, photographic record.
- Observation of position at rest and on exertion, and reported range of movement during sleep.
- Assessment of tone and spasticity (Oxford Manual Muscle Testing Scale or Modified Ashworth Scale) in consultation with lead physiotherapist.

Assessment of baseline function

- Assessment of carer burden in personal care (reported or observed)
- Assessment of upper limb function (taken from AMPS, FIM+FAM, PEDI, MACS and clinical observations)

Evaluate/Consider:

- Potential compliance in prescription of intervention
- Other interventions
- Possible impact of splinting on participation on all activities

Interventions

- Ready-made elbow extension splint, or wrist and hand extension splint
- Custom-made elbow extension splint or wrist and hand extension splint
- Custom-made elbow, wrist and hand extension splint.

Strategies

- Programme to include aims of splint and application instructions
- Clear wearing regime
- Education of child, family and carers on rationale and application
- Attention to be given to aesthetic components for compliance and satisfaction
- Regular review of fit, compliance and progress, and adjustment

Performance measures

- Repeat assessment of tone and range of movement using base line tools
- Repeat assessment of function using baseline tools
- Measure range on splint with goniometer.

Review considerations

- Evaluate compliance, review possible alternative interventions and the impact of splinting on participation.
- Evaluate feedback from child, family and carers on impact/effect of splinting

Summary of the evidence
While there is clear evidence of the effectiveness of *casting* to maintain passive range of movement in the presence of increased tone (Prizzi et al, 2005, Moseley et al, 2008)*. Clinical experience at The Children's Trust demonstrates that casting can reduce access to other effective/valued activities including personal care, hydrotherapy, play and education. Therefore greater use of splinting has been adopted.

However, although static splinting is widely used following acquired brain injury, there is considerable variability in the design of splints provided, materials used and the recommended wearing protocol (Kilbride et al, 2013). In addition, there is considerable variability in the outcome measures utilised in research (See Appendix 1).

Upper extremity spasticity can result in extreme functional limitations, pain and skin integrity which can impact on a person's participation in activities of daily living (Denham 2008, WFOT, 2012). Restriction in range of movement can lead to changes in soft tissue structures such as shortening and increased stiffness (Lannin et al, 2003, Ada et al, 2006).

There is a general assumption that splinting is beneficial (Kilbride et al, 2013), and anecdotal evidence from highly specialist occupational therapists at The Children's Trust of both positive and negative episodes of intervention. There is some evidence in support of splinting to maintain upper limb range of movement in acquired brain injury (Prizzi et al, 2005, Adrienne et al, 2011, Copley et al, 2013) but little evidence to support the impact of splinting to maintaining range on function (Burtner et al, 2008). Several studies found that upper limb splinting was clinically unimportant (Lannin et al, 2003 and 2007, Basaran et al, 2012).

Numerous studies suggest that the lack of evidence in support of splinting reflects the heterogenous population, inadequate design, poor compliance and the use of inappropriate outcome measures (Lannin et al, 2003, Prizzi et al, 2005, Burtner et al, 2008). In addition, there is clear evidence that splint comfort, design and appearance impact significantly on compliance with wearing protocols (Kuipers et al, 2009, Jackman et al, 2014).

COT Guidelines on splinting adults issued in 2015 stress the need for clinical benefits of splinting to be determined through evidence gathered in OT practice. The Guidelines do not recommend routine splinting, but acknowledge that it may be beneficial in selected cases.

Clinical recommendation at The Children's Trust
There is not consensus evidence that static splinting is an effective intervention to help maintain upper limb range of movement in children following an acquired brain injury. It should not be used routinely. It is essential that clinicians follow the TCT Protocol for splinting and casting (Sept 2015) and should follow the Practice Guidelines for OTs and Physios (COT and ACPIN 2015).
Splinting should never be undertaken without the appropriate baseline assessment and clinical reasoning. In addition, there must be ongoing evaluation for every client for all splints. It is essential that occupational therapists at The Children's Trust collect data (according to the TCT protocol) to further the evidence base in this clinical field.

*see additional TCT evidence based guidelines for stretching

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Upper Limb Dynamic Splinting at The Children's Trust
Best practice recommendations
October 2016

Rationale
Dynamic splinting is a treatment method that can be used with adults and children with a variety of conditions to support or enable participation in grasp and release activities. Without hand function, the rest of the upper limb has reduced function. One of the main functions of the upper limb/hand is reach and grasp. A dynamic extension splint is an orthosis that positions the hand optimally for function and allows active flexion to grasp objects and then uses springs to return the fingers to extension to release. The hypothesis is that opportunities for repetitions in functional, task-oriented grasp and release activities improves motor learning, reduces learned non-use and improve hand function (motor learning and occupational engagement theory).

Clinical question – Is dynamic splinting an effective intervention to help improve upper limb function in children following an acquired brain injury?

Implications
Assessment of baseline tone, range of movement and strength
- Measurement of passive range of movement using goniometer or biometrics (use guidelines).
- Oddstock tracing, photographic record.
- Observation of position at rest and on exertion, and reported range of movement during sleep.
- Assessment of tone and spasticity (Oxford Manual Muscle Testing Scale or Modified Ashworth Scale) in consultation with lead physiotherapist.

Assessment of baseline function
- Assessment of carer burden in personal care (reported or observed)
- Assessment of upper limb function (taken from AMPS, FIM+FAM, PEDI, MACS and clinical observations)

Evaluate/Consider:
- Compliance and buy-in
- Education on motor learning and neuroplasticity
- Support, encouragement and motivation from family/carers
- Cost – time, resources, intensity and child's time/fatigue
- Effect of effort on tone and positioning
- Secondary complications following ABI and UL impairment (soft tissue shortening, learned non-use, weakness)
- Other possible interventions
- Possible impact of splinting on participation in other activities

Interventions
- Saebo products – SaeboFlex
- Custom-made dynamic splints
- The strength of the springs can be adjusted to accommodate the individual's strengths and needs, providing assistance or requiring active extension.

Strategies
- Clear goals and agreed expectations
- Log of home exercises
- Communication with MDT - Education of child, family and carers on rationale and application
- Programme to include aims of splint, application instructions, regime and activities

Performance measures
- Repeat assessment of tone, range of movement and strength using base line tools
- Repeat assessment of function using baseline tools
- Measure changes in spring tension

Review Considerations
- Evaluate compliance, review possible alternative interventions and the impact of splinting on participation.
- Evaluate feedback from child, family and carers on impact/effect of splinting

Summary of the evidence
No evidence was found for dynamic splinting in children with acquired brain injury (ABI). One study showed increased grip and dexterity amongst children with CP when using dynamic splints. The evidence summarized below is based on **adults** with stroke.

A number of studies were sourced that evaluated the use of dynamic splinting with adults with acquired neurological conditions. Much of the evidence is limited by small sample sizes and case reports. Some of the evidence has potential bias as it is supported or conducted by Saebo, the company who manufacture readymade dynamic hand splints. The research findings are difficult to synthesize due to the variety of intervention protocols. The training protocols ranged from a minimum of 45/60 minutes (Woo et al 2012, Barry poster, Sampson poster) up to a maximum of 6 hours per day (Farell et al 2007). The intervention lasted days (Farell et al 2007, Butler et al 2006), weeks (Barry poster, Woo et al 2012) and months (Sampson poster).

Wearing the dynamic splint was not evaluated as an intervention in itself. While the adults were wearing the splint they were involved in a number of activities including repeated task-orientated activities, grasp and release activities, real world activities, neuromuscular stimulation of weak wrist and finger extensors and exercises to improve strength, motor control and range of movement, particularly proximally (Farell et al 2007, Butler et al 2006). Some researchers reported general improvement in upper limb function (Samson poster, Barry poster) while others report specifically about impairment, muscle tone, wrist and finger movement, muscle catch angle and manual dexterity (Farell et al 2007, Butler et al 2006, Woo et al 2012, Jeon et al 2012, Deering poster). The results were inconclusive with some authors reporting no change (Farell et al 2007) and others reporting significant change (Woo et al 2012). Butler et al (2007) showed change over a 3 month period and included a measure of Quality of Life.

In addition to the direct evaluation of the dynamic splint some authors discussed the benefit of dynamic splinting in conjunction with other upper limb interventions. Constraint Induced Movement Therapy (CIMT) and some other bilateral task-orientated training is not accessible to all clients whose upper limb function is extremely limited. Using a dynamic splint may enable people with more significant upper limb impairments to participate in repeated, task oriented activities and thus improve arm function in a modified CIMT programme (Morfis, Bondon and Brown, poster, Jeon et al 2012).

Dynamic splinting involves costly resources and time from the clinician as well as significant time, motivation and buy-in from the client to carry out exercises independently. Clients need to be trained in using the dynamic splint and benefit from education on the supporting theories as well as support from those around them.

COT guidelines on splinting adults issued in 2015 stress the need for clinical benefits of splinting to be determined through evidence gathered in OT practice. The guidelines do not recommend routine splinting, but acknowledge that it may be beneficial in selected cases.

Clinical recommendation at The Children's Trust
Do not routinely offer dynamic splinting.
Consider use in conjunction with the modified constraint induced movement therapy or bimanual training.
Follow the TCT Protocol for splinting and casting (Sept 2015) and the Practice Guidelines for OTs and Physios (COT and ACPIN 2015).
Document baseline assessment, clinical reasoning and ongoing evaluation.
Analyse this group data to further the evidence base in this clinical field.

Upper limb task specific training at The Children's Trust
Evidence based summary-January 2018

Rationale

Task orientated, or task specific training, is the practicing the skills required for a task, with prompt feedback on performance (Hubbard, Parsons et al. 2009). There is still some debate over what constitutes a task (Bosch, O'Donnell et al. 2014), but it is generally considered that a task should be a real life, relevant activity, such as handwriting, feeding or tying shoelaces (Hubbard, Parsons et al. 2009). It is known that task specific training is important in typical motor learning (Schmidtt and Lee, 2005), however it is less clear as to whether this is a usual technique for relearning after an ABI.

Clinical question –

Should task specific training be offered to improve the upper limb function and participation of children receiving rehabilitation at The Children's Trust?

Assessment

- All children should have an upper limb assessment based on the CPUPS assessment
- Either the Melbourne Assessment of Unilateral Upper Limb Activity or the Assisted Hand Assessment should be used as part of the assessment
- Children should also be classified according to their MACS level as a functional classification.
- Goal setting is essential to select tasks that are important and meaningful to the child. Use of a tool such as COPM may be helpful (Hubbard, Parsons et al. 2009)

- **Intervention**

  - The task and environment need to be considered
  - Tasks need to be relevant to the child
  - Tasks need to be varied to aid generalisability into different situations
  - Whole tasks can be analysed, and broken down to concentrate on the areas that the child has difficultly, but must then be put back together. Alternatively whole tasks can be practiced
  - Feedback should be timely and positive, and gradually withdrawn so the child can generate their own feedback. (Hubbard, Parsons et al. 2009)

Summary of the evidence

<u>*Children with ABI*</u>

- . There is no evidence that has investigated task specific training in children with ABI.

<u>*Children with CP*</u>

* Systematic review looking at the use of task specific training to improve the gross motor function of children with CP found there was low quality, conflicting evidence as to whether it improved skill performance, function and participation (Toovey, Bernie et al. 2017)
* Goal directed training was recommended to improve upper limb function in children with CP in a systematic review by (Novak, Mcintyre et al. 2013)
* Children who have the receptive language skills of a 5 year old are able to set their own goals from which the tasks can be identified (Vroland-Nordstrand, Eliasson et al. 2016). Goal directed task training improves outcomes to a greater extent than use of activities that are not relevant to the child (Löwing, Bexelius et al. 2009).

<u>*Children with handwriting difficulties*</u>

* Task specific interventions are required to improve handwriting in children referred to OT services for handwriting difficulties (Hoy et al. 2011)

Adults who have had strokes

* Cochrane review found that task training produced a significantly better result in upper limb function than no treatment, or routine treatment, and that benefits were maintained a six months follow up, but not at twelve months follow up (French, Thomas et al. 2016).
* There was no significant differences between the results of adults who were in the acute, subacute or chronic stages (post six months) of stroke (French, Thomas et al. 2016) .
* There was no difference if tasks were broken down, or practiced as whole (French, Thomas et al. 2016).
* There were no significant differences between outcomes of patients receiving less than 20 hours of task training, compared to those receiving over 20 hours (French, Thomas et al. 2016)
* Task training did not improve upper limb daily performance any more than standard occupational therapy in adults who were at least 6 months post stroke. Doubling the dosage of task training interventions did not produce greater improvements in upper limb function (Winstein, Wolf et al. 2016)
* Movement kinematics are different when using real and functional objects as opposed to activities that have no meaning (Hubbard, Parsons et al. 2009)

Guidance derived from clinical experience at TCT

Children are able to identify relevant and meaningful goals that they would like to work on, with the appropriate aids/assistance**.** Developing task training programmes that the child can carry out throughout their day can lead to improved functional outcomes.

Child and family experiences

Upper limb tasks such as writing, feeding themselves and getting dressed are common areas of priority for children. Parents are often keen for strategies to help their children develop skills, so can be taught how to practice the task/part of the task with their child.

Clinical recommendation at The Children's Trust

Assess child/young person's upper limb function on admission using standardized measures where possible

Explore child and family preference of rehabilitation interventions

Consider use of task orientated training if the child has specific tasks they would like to achieve.

Consider the environment in which the child is going to practice the task.

Consider how feedback of performance is going to be given, and how this can be continued throughout the child's day.

Monitor outcomes and collect data to further develop knowledge in this field.

Strengthening interventions at The Children's Trust
Best practice recommendations
January 2017

Rationale
It is known that muscles of children with cerebral palsy (CP) are weak (Pak and Kim 2014) and clinically, this is seen to be the case for children with Acquired Brain Injuries (ABI). Muscle weakness has been shown to be a major factor limiting motor performance in other neurological populations (Pak and Patten 2008). Interventions targeting strengthening the muscles of children with ABI may therefore improve their physical abilities, and thus their ability to participate in their daily lives.

Clinical questions – Should strengthening interventions be offered as part of the rehabilitation programme for children with ABI at The Children's Trust? Which interventions are most appropriate?

Assessment
All children should have a full individually tailored assessment of their physical abilities. This should include the gross motor function measure (GMFM) plus an additional measure relevant to their level of their physical functioning. This could include the 10m walk test, or movement ABC.

Intervention
A variety of interventions are aimed at strengthening muscles. Although many therapeutic interventions include an element of strengthening, this review considers those that are specifically aimed at increasing muscle strength. These are progressive resisted strength training and electrical stimulation (ES). Functional electrical stimulation (FES) will not be considered as this aims to improve functional movement patterns as opposed to pure strengthening.

Summary of the evidence
Children with ABI

- None Available

Children with CP

- There are discrepancies in findings of systematic reviews with some finding positive effects for strengthening (Pak and Kim 2014; Vershunen et al. 2011) and some finding no significant effects (Scillino et al. 2009)
- The best quality review was the systematic review and meta-analysis by Park and Kim (2014) which only included high quality RCT's.
- Electrical stimulation, progressive resisted strength training and aerobic exercise with strengthening (such as cycling), all displayed significant benefits for performance on the GMFM, individual muscle testing, sit to stand and stair climbing (Pak and Kim 2014).
- Electrical Stimulation had appeared to have the largest treatment effects, although direct comparison is challenging due to the differences in the studies (Pak and Kim 2014).
- Progressive strength training had a greater effect on specific muscle strength and activities that cardiovascular strengthening exercises such as cycling (Pak and Kim 2014)
- Strengthening did not improve walking speed (Pak and Kim 2014).
- Younger children responded had larger treatment effects than adolescents (Pak and Kim 2014).
- Strengthening interventions did not increase spasticity (Pak and Kim 2014).
- Not sufficient evidence for any recommendations for upper limb strengthening interventions (Pak and Kim 2014)

Adults who have had strokes

- Strengthening interventions had a statistically significant effect on gait speed (Pak and Patten 2008) and specific muscle strength, with resistance training having the greatest effect (Pak and Patten 2008)
- Strengthening interventions produced significant improvements on self-perceived measures of limitations and quality of life (Pak and Patten 2008)
- Strengthening interventions did not produce an increase in spasticity (Pak and Patten 2008)
- Adults with severe impairments did not benefit from strengthening interventions (Moreland et al. 2003).
- Specific resisted strength training demonstrated greater benefits with moderate upper limb impairments rather than mild impairments (Harris and Eng 2010), although all levels of impairments had some benefits.
- Significant effects in sub-acute and chronic stages post stroke (although possibility of type 2 error in chronic group as there are only five trials) (Harris and Eng 2010)

- No evidence to suggest strengthening has a direct impact on independence in ADL (Harris and Eng 2010).
- Strength training increases restoration of motor function whereas task training increased compensation, with strength training followed by functional training producing the greatest overall benefits (Corti et al. 2012)

Typically developing children

- Pre- adolescent children display benefits in motor unit recruitment and firing rate and coordination of muscle activity, with less changes in the muscles themselves
- Adolescents respond in a similar way to adults with changes in muscle bulk seen.

Recommendations for strengthening protocols

- Insufficient specific evidence to make firm recommendations (Vershunen et al. 2011), with no studies directly comparing different strengthening protocol (Pak and Patten 2014).
- Studies indicate that 6-8 weeks, 3 times a week, for 30-40 minutes, with sufficient resistance to allow completion of 8 exercises before fatiguing, and completing 3 sets of each exercise (Vershunen et al. 2011; Pak and Patten 2008).
- Use electrical stimulation as an adjunct if children are unable to move against gravity (Pak and Kim 2014).

Summary

Although there is no evidence for use of strengthening interventions with children with ABI, they are likely to improve both muscle strength and physical functioning of children with ABI. They should therefore be considered as part of the child's physical rehabilitation programme. There is sufficient information from past studies to guide the parameters for strengthening interventions, however optimum interventions are not yet known.

Clinical recommendation at The Children's Trust

Assess child/young person's strength and physical activities on admission using standardized measures where possible

Explore child and family preference of rehabilitation interventions

Consider a lower limb/ upper limb progressive strength training programme to improve physical activity in children with moderate or mild impairments. This should include resistance (weights/gravity) so that children can complete 8 repetitions of the movement, and complete 3 sets, 3 times a week for 6 to 8 weeks

Consider electrical stimulation for children who do not have sufficient strength to move

Virtual reality at The Children's Trust
Best practice recommendations
June 2017

Rationale
Virtual reality has been defined as "use of interactive simulation created by computers to present users to engage in environments that appear and feel similar to real world objects and events (Weiss 2006). These can either involve commercially available games consoles, such as the Wii, or specially created devices such as the Tomoko or Biometrics. Virtual reality is believed to be useful within rehabilitation as it can allow active task training within fun and motivating activities.

Clinical question – How and when should virtual reality be used within rehabilitation programmes at The Children's Trust?

<u>Assessment</u>

An individualised assessment of the child's impairments, functioning and goals should be completed to identify the rationale for using virtual reality, and be able to monitor outcomes.

<u>Summary of the evidence</u>

There has been little research investigating the use of the virtual reality in the rehabilitation of children with ABI, except for some early research in its use for gross motor skills. Research from literature studying both adults with stroke and children with cerebral palsy is also considered.

<u>Upper limb</u>

- Early research indicates that use of virtual reality can improve functional upper limb outcomes for children with CP (Chen et al. 2014: Ravi et al. 2016)
- A Cochrane review of the adult stroke literature indicated that inclusion of virtual reality as an adjunct to, or in place of conventional therapy may improve upper limb function and use in ADL (Laver et al. 2015).
- Factors indicating a more favourable outcome include patients with mild to moderate deficits, and who had access to more than 15 hours a week of treatment (Laver et al. 2015).
- Use of all virtual reality methods appear to be of benefit, but no evidence as to which type is the most effective for patients with different levels of functioning (Proenca et al. 2017; Laver et al. 2015)
- Study comparing virtual reality to recreational games indicated there is no difference in outcomes, and hypothesised that any added intensity of upper limb practice will be beneficial (Saposnik, 2016).

<u>Gross motor skills</u>
- Systematic review by Baque et al (2016) showed prelimary evidence that the wii and kinect improve the gross motor skills of ambulant children following ABI (limited in quality and quantity at present).
- Moderate evidence suggesting virtual reality improves balance in children with CP (Ravi et al. 2016)
- Balance training with virtual reality by Wii Fit produced better benefits than standard balance training alone for adults with stroke (Corbetta et al. 2015)

<u>Gait</u>

- Use of virtual reality treadmill training system improved gait speed over standard treatment alone in adults with stroke (Corbetta et a. 2015)

<u>Cognition</u>

- Use of virtual reality increases motivation and compliance with rehab programmes (Howard 2017)
- Insufficient studies investigating cognitive outcomes completed in stroke rehabilitation to recommend its use (Laver et al. 2015).
- May be beneficial to improve attention and memory for adults with acquired brain injuries (Shin and Kim, 2015)

<u>Use at The Children's Trust</u>

- Variety of virtual reality systems available including gaming consoles, Wii, Wii fit, Tomoko and Biometrics that could be used to target different outcomes for children with different levels of ability.

Clinical recommendation at The Children's Trust

- **Consider use of virtual reality in addition to standard rehabilitation to improve upper limb and gross motor outcomes, and memory and attention, if it is a motivating activity for the child.**
- **Aim for as high intensity as possible, ideally over 15 hours a week**
- **Select the type of virtual reality, and programme based on an assessment of the child's needs, and their likes and preferences.**
- **Monitor outcomes and adjust programmes accordingly.**