The Effects of Serial Casting Duration on Ankle ROM and Mobility in Ambulatory Children with Spastic Cerebral Palsy

Systematic Review Final Report

RSPT 572
Supervisor: Kathy Davidson

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Cerebral Palsy

- A non-progressive disorder caused by brain lesions prenatally, perinatally or postnatally (0-2 yrs)
- Most common cause of neuromuscular disability in children
- Cerebral Palsy (CP) is classified as spastic, ataxic or dyskinetic
Cerebral Palsy

- Spastic Cerebral Palsy:
  - Most prevalent (77%)
  - Hypertonia
    - ↑ interdigitation of actin and myosin
  - Development of contractures
  - Immobility around the joint
    - muscle atrophy, connective tissue weakness, and ↑ resistance to stretch
  - Development of an equinus gait
    - Dynamic non-fixed equinus → Fixed equinus

(1, 2)
<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level I</td>
<td>Walks without Limitations</td>
</tr>
<tr>
<td>Level II</td>
<td>Walks with Limitations</td>
</tr>
<tr>
<td>Level III</td>
<td>Walks Using a Hand-Held Mobility Device</td>
</tr>
<tr>
<td>Level IV</td>
<td>Self-Mobility with Limitations; May Use Powered Mobility</td>
</tr>
<tr>
<td>Level V</td>
<td>Transported in a Manual Wheelchair</td>
</tr>
</tbody>
</table>

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Tel: 905-525-9140 ext. 27850 Fax: 905-522-6095
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Treatment Options

Treatments for the prevention and management of contractures include:

- **Invasive**
  - Surgery (eg. Tendon lengthening)
  - Botulinum Toxin A

- **Non-Invasive**
  - Manual Short Duration Stretching
  - Prolonged Stretching Methods
    - Serial casting
    - AFOs
    - Splinting

(4, 5)
Surgical Intervention

- Surgical tendon release is a common method used to treat spastic muscles
  - Best if performed after 6 years of age
    - 50% reoccurrence if surgery under 3 years of age
  - Risks of surgery:
    - Over-lengthening
    - Infection
    - Scarring
    - Side-effects of anaesthesia
Botulinum Toxin A

- Injections are fast and have few side-effects
- Reported benefits:
  - Increased ROM
  - Decreased Spasticity
  - Improved Function
- Not always available outside of urban areas
- Expensive especially if no insurance
- Require specialist appointments
  - ↑ Wait times
Manual Short Duration Stretching

- Non-pathological muscle usually held >20sec
  - Spastic muscles, no long-lasting clinical benefits in:
    - ROM, Mobility, Contracture risk, Decreased spasticity
  - Still has place as adjunct to other therapy for:
    - Muscle cramps
    - Joint lubrication
    - Changing position
    - Fitting devices

(7, 8)
Serial Casting Guidelines

- Research shows >6hr required to prevent contracture development
- Casting is a good way to achieve long-term stretch:
  - No specific guidelines for serial casting for this clinical population
  - In general, clinically recommended 1-4 progressions of 7-10 days
  - Supplement casting with:
    - Physiotherapy
    - Heel-cord lengthening
    - Balance training
    - Night splint & AFO usage.
What is the most effective prolonged stretch intervention duration to treat children with spastic Cerebral Palsy?

**Primary Aim**
- To determine if serial casting has an effect on passive dorsiflexion range of motion (PROM) in children with spastic CP.

**Secondary Aim**
- To determine if serial casting has an effect on spasticity, gait, and functional mobility in children with spastic CP.

**Secondary Aim**
- To explore whether the different intensities and durations of casting impact the effect of casting and its sustainability.
**PICO:**

| **P** | Ambulatory children with spastic cerebral palsy  
|       | • Level I-III on GMFCS  
|       | • 0-18 years old |
| **I** | Serial casting with or without follow-up treatment |
| **C** | The effect of different serial casting parameters on outcomes |
| **O** | Dorsiflexion PROM, spasticity, gait characteristics, and function |
Search Strategy

4 search streams were combined to address the research question:

- **Children with Spastic Cerebral Palsy**
  - (cerebral palsy)
  - (spastic* OR tone OR hyperton* OR contracture)

- **The Ankle Joint**
  - (ankle OR dorsiflex* OR soleus OR gastroc* OR triceps surae OR equinus OR toe-walk OR lower extremity)

- **Serial Casting Interventions**
  - (serial cast* OR prolong* OR sustain* OR long duration OR stretch* OR passive)
Search Strategy – Inclusion/Exclusion

Studies Included
- MEDLINE
  - Limit Age, English, Human
  - 137 Studies (0 Doubles)
  - Total Excluded Due to Abstract/Title: 127
  - Exclusion Criteria: 3

Studies Included
- EMBASE
  - Limit Age, English, Human
  - 97 Studies (71 Doubles)
  - Total Excluded Due to Abstract/Title: 22
  - Exclusion Criteria: 2

Studies Included
- CINAHL
  - Limit Age, English, Human
  - 45 Studies (41 Doubles)
  - Total Excluded Due to Abstract/Title: 4
  - Exclusion Criteria: 0

Studies Included
- SPORTDiscus
  - Limit English
  - 31 Studies (25 Doubles)
  - Total Excluded Due to Abstract/Title: 5
  - Exclusion Criteria: 1

Studies Included
- psycINFO
  - Limit Age, English, Human
  - 15 Studies (15 Doubles)
  - Total Excluded Due to Abstract/Title: 0
  - Exclusion Criteria: 0

Studies Included
- Cochrane (CDSR)
  - No Limits Available
  - 12 Studies (0 Doubles)
  - Total Excluded Due to Abstract/Title: 9
  - Exclusion Criteria: 3

Studies Included
- DARE
  - No Limits Available
  - 5 Studies (0 Doubles)
  - Total Excluded Due to Abstract/Title: 4
  - Exclusion Criteria: 1

Studies Included
- Grey Literature
  - Limit Age, English, Human
  - 23 Studies (8 Doubles)
  - Total Excluded Due to Abstract/Title: 6
  - Exclusion Criteria: 7

Total Studies Included for Systematic Review: 11

Further Data Extraction And Analysis

Total Excluded Studies From Systematic Review: 346
EMBASE
(1980 to present, daily updates)
Search Results Rendered:
\( n = 196 \)

Non-Human, Non-English and Improper Age of Participants (Not 0-18 years):
\( n = 99 \)

Duplicate Results Compared to Other Search Databases Already Rendered:
\( n = 71 \)

Studies to be Assessed Based on Title, Abstract and Inclusion/Exclusion Criteria:
\( n = 26 \)

Studies Removed due to Title:
\( n = 21 \)

Studies Removed due to Abstract:
\( n = 1 \)

Studies Removed due to Assessment of Inclusion/Exclusion Criteria:
\( n = 2 \)

Studies to be Included in the Systematic Review and Undergo Data Extraction:
\( n = 2 \)
Inclusion Criteria

- All study types
  - RCT, individual cohort, case-control/series, before-and-after
- All study publication dates (no limits)
- Studies involving children with spastic CP:
  - 0-18 years old
  - Level I-III on GMFCS (“Ambulatory”)
- Limited dorsiflexion ROM and/or equinus walking
  - Studies must include ROM as an outcome measure
- Studies examining effect of serial casting on ankle ROM, walking abilities, and/or functional activities
- Studies with participants undergoing concurrent treatments can still be included as long as this alternative treatment is not the focus of the study.
Exclusion Criteria

- Studies not investigating the ankle joint
- Non-English studies
- Studies involving non-human participants
- Studies focusing on effects of recent surgeries, recent Botox treatment, or concurrent alternative treatments
- Studies scoring “5” on the AACPDM level of evidence scale
- Studies scoring less than 16/32 on the Downs and Black Quality Assessment Scale
Quality Assessment: (1) Methodological Assessment

Downs & Black Checklist (1998):

- Based on 5 aspects of quality
  1) Reporting
  2) External validity
  3) Internal validity (selection bias and blinding)
  4) Confounding
  5) Power
- Can be used for RCT and non-RCT
- Good inter-rater reliability

<table>
<thead>
<tr>
<th>External Validity</th>
<th>yes=1, no=0, unable to determine=0</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Were the subjects asked to participate in the study representative of the entire population from which they were recruited?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Were those subjects who were prepared to participate representative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Were the staff, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internal validity -bias</th>
<th>yes=1, no=0, unable to determine=0</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Was an attempt made to blind study subjects to intervention they have received?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Was an attempt made to blind those measuring the main outcomes of the intervention?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Quality Assessment: (2) Levels of Evidence

### AACPDPM Levels of evidence (1999):
- Based on Oxford scale
- Adapted for CP and developmental disability research
- Developed for heterogeneous populations and ↓ incidence
- Can be used for single study design

<table>
<thead>
<tr>
<th>Level</th>
<th>Non-empirical</th>
<th>Group Research</th>
<th>Outcomes Research</th>
<th>Single Subject Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
<td>Randomized controlled trial All or none case series</td>
<td>N-of-1 randomized controlled trials</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>Nonrandomized controlled trial Cohort study with concurrent control group</td>
<td>Outcomes research analytic survey</td>
<td>Multiple phases (treatment/no treatment) design Alternating treatments Multiple baseline across ≥3 subjects</td>
</tr>
<tr>
<td>III</td>
<td></td>
<td>Case-control study Cohort study with historical control group</td>
<td></td>
<td>ABA design</td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td>Before and after case series without control group</td>
<td></td>
<td>AB design</td>
</tr>
<tr>
<td>V</td>
<td>Descriptive (after) case series or reports Anecdotes Expert opinion without explicit critical appraisal (or testimony) Theory based on physiology, bench, animal research Common sense/first principles</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data Extraction

- Standardized forms completed independently by 2 reviewers:
  - (1) Study Characteristics
    - Title, author, year, quality assessment score, level of evidence, study setting, and recruitment strategies
  - (2) Traits of Participant
    - Age, GMFCS level, number of participants / drop-outs
  - (3) Serial Casting Parameters
    - Details on intensity of stretching, total treatment time, number of castings
  - (4) Study outcomes
    - Primary outcome: DF ROM
    - Secondary outcomes ("others"): Spasticity, gait, function

- Any disagreements were arbitrated by an impartial 3rd team member
## Data Extraction - Example

### INTERVENTION:

<table>
<thead>
<tr>
<th>DF Stretch Type</th>
<th>Manual / Short Duration Stretch</th>
<th>Prolonged / Device-Assisted Stretch</th>
<th>Alternative Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Serial Casts (short-leg fiberglass walking cast)</td>
<td>Serial Casts (short-leg fiberglass walking cast)</td>
<td>Serial Casts (short-leg fiberglass walking cast)</td>
</tr>
<tr>
<td>Hold time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>hrs/day</td>
<td>24 hrs/day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td>Mid-way between R1 &amp; R2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of Intervention</td>
<td>3-6 wks (3 x 1-2 wks progressions)</td>
<td>3-6 wks (3 x 1-2 wks progressions)</td>
<td></td>
</tr>
</tbody>
</table>

### OUTCOME:

<table>
<thead>
<tr>
<th>(1) ROM</th>
<th>Group #1</th>
<th>Group #2</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method of Measure</td>
<td>Specify: CP</td>
<td>Specify: ITW</td>
<td>* Are these changes in ROM significant at 6 wks post-Tx?</td>
</tr>
<tr>
<td>Pre-Tx</td>
<td>Rotating foot plate</td>
<td>Rotating foot plate</td>
<td></td>
</tr>
<tr>
<td>4.6 deg of DF (SD 1.7)</td>
<td>3.5 deg of plantarflex (SD 2.6)</td>
<td>9.5 deg of DF (SD 1.4)</td>
<td></td>
</tr>
<tr>
<td>Post-Tx</td>
<td>16.5 deg of DF (SD 1.4)</td>
<td>9.5 deg of DF (SD 1.4)</td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>Increased DF ROM</td>
<td>Increased DF ROM</td>
<td></td>
</tr>
<tr>
<td>p value</td>
<td>p&lt;0.001</td>
<td>p&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>f/u results</td>
<td>f/u at 6 wks: 10.7 deg of DF (SD 1.9)</td>
<td>f/u at 6 wks: 11.6 deg of DF (SD 2.1)</td>
<td></td>
</tr>
</tbody>
</table>

Study Characteristics

- 11 papers included in the SR
- Study designs:
  - RCT, outcome research (before & after), retrospective research
  - AACPDM levels of evidence 1, 2, & 4
  - Downs & Black scores: 21-28/32
- Published between 1986 & 2006
- Subject information:
  - n = 7-28
  - Mean ages: 2.58 years to 9.40 years
    - Mostly 4 years to 7 years
Study Characteristics

- **Casting procedures:**
  - **Cast types:**
    - Lightweight & fibre-glass; below knee & short-leg walking casts
  - **Intensity of stretch:**
    - Neutral DF, 0-5° or 0-10° DF, midway between R1 and R2, and to max DF
  - **Duration of casting:**
    - Totals: 2.8 weeks – 6 weeks
    - Casts changed every 1-3 weeks

- **Additional treatments:**
  - 6 studies used stretching devices post-casting
    - AFOs, night splints/plasters, bi-valved fibre-glass splints
# ROM - Results

<table>
<thead>
<tr>
<th>Study</th>
<th>O weeks</th>
<th>Follow-Ups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Changes</td>
<td>Significant?</td>
</tr>
<tr>
<td>Ackman et al. (2005)</td>
<td></td>
<td>p ≤ 0.03*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 m</td>
</tr>
<tr>
<td>Booth et al. (2003)</td>
<td>5.54° (± 3.87) per week</td>
<td></td>
</tr>
<tr>
<td>Brouwer et al. (2000)</td>
<td>11.9°</td>
<td>p &lt; 0.01*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p &lt; 0.01*</td>
</tr>
<tr>
<td>Corry et al. (1998)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>KE: p = 0.047*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# ROM - Results

<table>
<thead>
<tr>
<th>Study</th>
<th>0 weeks</th>
<th>Follow-Ups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Changes</td>
<td>Significant?</td>
</tr>
<tr>
<td>Flett et al. (1999)</td>
<td></td>
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<tr>
<td>Glanzman et al. (2004)</td>
<td>15.0° (± 4.5)</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Kay et al. (2004)</td>
<td></td>
<td></td>
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<tr>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>McNee et al. (2006)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Right: ↑ 8.8°</td>
<td>p &lt; 0.005*</td>
</tr>
<tr>
<td></td>
<td>Left: ↑ 10.3°</td>
<td>(bilateral)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watt et al. (1986)</td>
<td>Right: ↑ 8.8°</td>
<td>p &lt; 0.005*</td>
</tr>
<tr>
<td></td>
<td>Left: ↑ 10.3°</td>
<td>(bilateral)</td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
ROM – Results

• All eleven studies showed short term increase in DF ROM post casting

• General Trends:
  ◦ Range: $7.55^\circ$ to $16^\circ$
  ◦ Most numbers between $10^\circ$ and $13^\circ$
  ◦ Largest mean change ($15-17^\circ$)- casted at maximal DF
  ◦ Most common protocol: 3-4 week casting, casts changed every 1-2 weeks
ROM – Discussion

• Large variation in methodology

• 8 completed follow-up assessments
  ◦ 5/8 Significant maintenance of ROM at follow-up
  ◦ ROM gains lasted between 12 weeks & 6 months

• 6 used a stretching device post-casting
  ◦ 4/6 Significant maintenance of ROM at follow-up
  ◦ May influence long-term maintenance of ROM

• Unclear if any one casting protocol is superior

(3, 5, 9, 10, 14 - 17)
# Spasticity - Results

<table>
<thead>
<tr>
<th>Study</th>
<th>Measure</th>
<th>RESULTS</th>
<th>0 weeks</th>
<th>Follow-Ups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ackman et al. (2005)</td>
<td>MAS &amp; Tardieu</td>
<td>3 weeks</td>
<td>p ≤ 0.02*</td>
<td>3 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 weeks</td>
<td>p &lt; 0.02*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5 months</td>
<td>p &lt; 0.02*</td>
</tr>
<tr>
<td>Brouwer et al. (2000)</td>
<td>Resistance to Passive Stretch</td>
<td>6 weeks</td>
<td>p &lt; 0.005*</td>
<td>6 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>p &lt; 0.05*</td>
</tr>
<tr>
<td>Brouwer et al. (1998)</td>
<td>Resistance to Passive Stretch</td>
<td>6 weeks</td>
<td>p &lt; 0.01*</td>
<td>6 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>p &lt; 0.05*</td>
</tr>
<tr>
<td>Corry et al. (1998)</td>
<td>Ashworth Scale</td>
<td>2 weeks</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 weeks</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Flett et al. (1999)</td>
<td>MAS</td>
<td>1-3-5 months</td>
<td>p &lt; 0.001* (ANOVA across time)</td>
<td></td>
</tr>
<tr>
<td>Kay et al. (2004)</td>
<td>MAS</td>
<td>3 months</td>
<td>p = 0.0031*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 &amp; 12m</td>
<td>Significant (no p-values)</td>
<td></td>
</tr>
</tbody>
</table>
Spasticity - Results

- 5/6 studies showed significant reduction in spasticity post-casting
  - Brouwer et al. (1998): 0 & 6 weeks
  - Brouwer et al. (2000): 0 weeks
  - Ackman et al. (2005): Up to 5 months
  - Flett et al. (1999): Up to 6 months
  - Kay et al. (2004): Up to 12 months
- Corry et al. (1998): No significant changes at 2 weeks & 12 weeks

(5, 10, 11, 15, 17, 21)

Use of AFOs, night splints, and/or PT post-casting
Spasticity - Discussion

- No major differences in casting parameters between studies:
  - 3-6 weeks of total casting
  - Casted at 0-10° DF
  - Level I-III GMFSC
  - Why didn’t Corry et al. (1998) find significance?

- Differences in mean ages?
  - 5 studies with “significance”: 3y 6m to 9y 4m
  - Corry et al. (1998): 4y 7m
  - Casting more effective in slightly older age group?
  - Overlap in mean ages & limited number of studies, therefore difficult to draw conclusions
Spasticity - Discussion

- Does the use of night splints, AFOs, and/or PT assist in the maintenance of improvements?
  - The three studies which used stretching devices post-casting had the longest lasting effects (5-12 months)
    - Consistent with Tardieu et al. in 1988
  - The two significant studies which did not use stretching devices did not have follow-up beyond 6 weeks
    - Unknown if improvements maintained without their use
# Temporospatial - Results

<table>
<thead>
<tr>
<th>Study</th>
<th>Measure</th>
<th>Outcome</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 weeks</td>
</tr>
<tr>
<td>Ackman et al. (2005)</td>
<td>Vicon Motion System</td>
<td>Stride Length</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Velocity</td>
<td>ns</td>
</tr>
<tr>
<td>Brouwer et al. (2000)</td>
<td>Sagittal Barefoot Walking</td>
<td>Stride Length</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Velocity</td>
<td>ns</td>
</tr>
<tr>
<td>McNee et al. (2006)</td>
<td>3-D Vicon Motion Capture System</td>
<td>Stride Length</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Velocity</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cadence</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>% Single Support</td>
<td>$p = 0.05^*$</td>
</tr>
</tbody>
</table>
Three studies used video gait analysis to look for improvements in stride length and velocity during gait
  ◦ Two studies followed up with AFOs; one study did not mention AFO use post treatment
  ◦ None of these studies found significant improvements immediately post-casting, or at any follow-up assessment for any temporospatial measure
## Ankle Kinematics - Results

<table>
<thead>
<tr>
<th>Study</th>
<th>Measure</th>
<th>Outcome</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ackman et al. (2005)</td>
<td>Vicon motion System</td>
<td>DF at initial contact</td>
<td>0 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>p ≤ 0.007*</td>
<td>3w, 6w, 5m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max DF in stance</td>
<td>3w, 6w, 5m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DF in swing</td>
<td>3w, 6w</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5m</td>
</tr>
<tr>
<td>Corry et al. (1998)</td>
<td>3-D Vicon motion capture system</td>
<td>DF at initial contact</td>
<td>2 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max DF in stance</td>
<td>2 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12 weeks</td>
</tr>
<tr>
<td>Kay et al. (2004)</td>
<td>3-D Vicon motion capture system</td>
<td>Max DF in stance</td>
<td>3 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6m, 12m</td>
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<tr>
<td></td>
<td></td>
<td>DF in swing</td>
<td>3 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6m, 12m</td>
</tr>
<tr>
<td>McNee et al. (2006)</td>
<td>3-D Vicon motion capture system</td>
<td>Max DF in stance</td>
<td>p = 0.01*</td>
</tr>
</tbody>
</table>
Ankle Kinematics – Results

- 4 studies used video gait analysis to monitor changes in ankle kinematics, including:
  - Dorsiflexion at initial foot contact
  - Peak dorsiflexion in stance and in swing
  - Overall maximum dorsiflexion during gait

- All 4 studies found significant improvements in ankle kinematics
  - 2 remained significant at 12 weeks (Ackman; Kay)
  - 2 no longer significant at 12 weeks (Corry; McNee)
Do improvements from serial casting translate to improved dynamic ROM?

- 2 studies maintained significant improvements
  - Subjects wore night splits or AFOs post-casting (Ackman; Kay)
  - Splinting may have influenced maintenance of improvements

- 2 studies improvements were NOT significant at 12 weeks
  - Corry et al. (1998) did not allow splint use post-casting
  - McNee et al. (2006) 6 of 9 subjects wore AFOs post-casting

- Conflicting evidence – cannot draw conclusions

- General trend towards improvement in dynamic ROM
### Qualitative Measures of Gait - Results

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcome</th>
<th>Measure</th>
<th>0 weeks</th>
<th>Follow-Ups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brouwer et al. (2000)</td>
<td>“Toe-Walking”</td>
<td>Sagittal barefoot walking</td>
<td>8/8 plantigrade (no p-value)</td>
<td>6 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2/8 reverted back to digitgrade (no p-value)</td>
</tr>
<tr>
<td>Corry et al. (1998)</td>
<td>Gait improvements</td>
<td>PRS scale</td>
<td></td>
<td>2 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>p = 0.016*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rated “change”</td>
<td></td>
<td>12 weeks</td>
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<td></td>
<td></td>
<td></td>
<td>ns</td>
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<tr>
<td></td>
<td></td>
<td>PRS total score</td>
<td></td>
<td>2 weeks</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>p = 0.039*</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>12 weeks</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>p = 0.031*</td>
</tr>
<tr>
<td>Cottalorda et al. (2000)</td>
<td>“Toe-Walking”</td>
<td>Observation</td>
<td>30/30 feet: ↑ heel-toe or flat foot gait</td>
<td>1-3-5 months (ANOVA across time)</td>
</tr>
<tr>
<td>Flett et al. (1999)</td>
<td>Global Score Scale (GSS)</td>
<td>2-D video gait analysis</td>
<td></td>
<td>1-3-5 months (ANOVA across time)</td>
</tr>
<tr>
<td></td>
<td>Physician Rating Scale (PRS)</td>
<td>2-D video gait analysis</td>
<td></td>
<td>p &lt; 0.001*</td>
</tr>
<tr>
<td>Watt et al. (1986)</td>
<td>“foot-floor” contact during gait</td>
<td>Video observation</td>
<td>p &lt; 0.05* (bilateral)</td>
<td>2 weeks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Right foot: p &lt; 0.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 months</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Left foot: ns</td>
</tr>
</tbody>
</table>
Qualitative Measures of Gait – Results

Five studies investigated the effect of serial casting on qualitative gait changes; all showed short term improvements

- Observation of barefoot standing and walking
  - Brouwer et al. (2000):
    All subjects displayed improved gait patterns post-casting
    • Not stated if improvements sustained at 6 weeks, however 2 subjects returned to equinus gait
  - Cottalorda, et al. (2000):
    All subjects showed improved function in heel-toe gait
    • 2/3 improvements remained significant at 18 months
  - Watt, et al. (1986):
    Significant improvement in foot contact in stance
    • More subjects displayed improved right foot contact at 5 months post than left foot contact
    • Authors were unable to explain the difference between right and left sides
Qualitative Measures of Gait – Results

- Video gait analysis rated by the Physicians Rating Scale (PRS)
  - Corry, et al. (1998)
    - Significant improvement in PRS rating for foot contact at 2 weeks; not significant at 12 weeks.
    - Significant change in overall PRS rating for crouch, knee, and foot contact at 2 weeks, remained significant at 12 weeks
  - Flett, et al. (1999)
    - Significant improvement in PRS rating for crouch and foot contact over time (2, 4, 6 months post-casting).
Qualitative Measures of Gait – Discussion

- Conflicting evidence for the effectiveness of serial casting on qualitative gait changes
- Difficult to compare and draw conclusions
- It appears that serial casting can be effective at improving the quality of gait in children with CP
- Longevity of improvements unclear
  - It can be inferred that serial casting appears effective for improving gait when short-term splinting is used post-casting

(5, 14, 16)
## Function - Results

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcome</th>
<th>Measure</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0 weeks</td>
</tr>
<tr>
<td>Cottalord a et al.</td>
<td>Parental satisfaction</td>
<td>Rated “improvement” by parents</td>
<td>18/20: “significant” 2/20: “moderate”</td>
</tr>
<tr>
<td>(2000)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flett et al. (1999)</td>
<td>Gross Motor Functional Measure (GMFM)</td>
<td>GMFM: Standing &amp; Dynamic subscales</td>
<td>1-3-5 months</td>
</tr>
<tr>
<td></td>
<td>Functional improvement</td>
<td>Parental report</td>
<td>1-3-5 months</td>
</tr>
<tr>
<td></td>
<td>Functional Improvement</td>
<td>Clinician evaluation</td>
<td>6/6 showed improvements</td>
</tr>
<tr>
<td>Kay et al. (2004)</td>
<td>Gross Motor Functional Measure (GMFM)</td>
<td>GMFM percent score</td>
<td>3 m</td>
</tr>
<tr>
<td>Watt et al. (1986)</td>
<td>Developmental motor skills</td>
<td>Assessment &amp; inventory of motor skills</td>
<td>2 weeks</td>
</tr>
</tbody>
</table>
Function - Results

4/5 studies showed some kind of functional improvement post-casting

- Parental Reports:
  - Cottalorda et al. (2000): 18/20 significant & 2/10 moderate “improvements”
  - Glanzman et al. (2004): 6/6 satisfied with results

- Clinician Report:
  - Glanzman et al. (2004): 6/6 improvements in function (mostly parameters in gait)

- GMFM:
  - Flett et al. (1999): 1, 3, 5 months
  - Kay et al. (2004): 6, 9, 12 months, 3 months

- Watt et al. (1986): No significant improvements in Developmental Motor Skills Tool at 2 weeks or 5 weeks
- Flett et al. (1999): only 2/10 “general improvements” (parental report)
Function - Discussion

GMFM:

- Two studies found improvements, but at different times:
  - Flett: significant at 1, 3, 5 m
  - Kay: significant at 6, 9, 12 m, but not at 3 m
- Both casted at neutral DF and used stretching devices post-casting
- Why different?
  - Differences in age?
    - Flett: 3.56 years  Kay: 7.1 years
  - Differences in casting procedures?
    - Flett: 4 weeks  Kay: 6 weeks
- Possible that changes observed due to normal developmental processes rather than casting procedures
- Further research is needed (only 2 studies!)
In general, most studies found improvements despite differences in casting parameters:
- 2.8 to 6 weeks of total casting
- Casted at 0-10° DF → Max DF

No major differences in interventions between studies which reported improvements and those that did not.

Difficult to compare studies because many outcome measures.
Conclusion: Summary of Evidence

Results from this SR indicate that:

1. Serial casting can be an effective non-invasive treatment option for improving dorsiflexion ROM and reducing spasticity in children with spastic CP.

2. These improvements may have some carry-over effect on gait quality and functional mobility.
   - Conflicting evidence of impact on ankle kinematics
   - No effect evident on stride length and velocity
3. No specific casting parameters have been identified:
   • In the majority of studies, casting for 3-6 weeks was found to be effective
   • Casts were changed weekly or biweekly
   • No indication of the “best” intensity of stretch

4. The use of AFOs and/or night splints post-casting may assist in the maintenance of improvements in ROM, spasticity, and gait quality.
   • This is consistent with Tardieu et al. in 1988
Limitations

Several factors made the comparison between studies difficult to execute:

1. **Differences in methodology:**
   - Casting parameters (duration & intensity)
   - Post-casting treatments
     - Poor control of post-casting treatments in some studies (e.g. 6/9 participants wearing AFOs).
   - Follow-up times (0 weeks → 3 years)

2. **Differences in outcome measures**
   - E.g. Different measures for “function”

3. **Differences in data reported**
   - E.g. ROM data presented as change in ROM with Standard Deviation and/or as p-values
Limitations

- The study of a clinical population also presents challenges:
  1. **Large variability between participants**
     - Differences between Level I & III, and within a single level
  2. **Small sample sizes**
  3. **Lower levels of evidence**
     - Well controlled rigorous studies are difficult to execute
       - Unethical to deny treatment in order to create a control group
       - Difficult to control for external influences
     - Note: this SR included several studies with an AACPDPM level 4 evidence
Clinical Implications

- The findings in this SR are consistent with the general guidelines for serial casting:
  - 1-4 progressions of 7-10 days
  - 3-6 weeks in total, with weekly to bi-weekly progressions
  - Follow-up casting with PT, stretching, strengthening, and night splints
    - The results from this SR indicate that the use of AFOs and night splints may prolong the results of casting.
    - Follow-up stretching devices are an important part of post-casting protocol.
Clinical Implications: a few new considerations

- **Duration of stretch**
  - Wide variety of total treatment times can be effective
  - Use clinical reasoning to determine the best number of progressions for each client.
  - Aim: To maximize the benefits & minimize any detrimental effects of prolonged immobilization.
    - “More is not always better”

- **Intensity of stretch**
  - Although casting in maximal dorsiflexion may result in larger gains at 0 weeks, there is no evidence that these improvements will be sustained.
  - It is important to consider client comfort
    - Casting at 0-10 degrees DF and at midway between R1 and R2 have also been shown to be effective.
    - “More may not be better”
Clinical Implications: one more consideration

- Adjunct treatments:
  - Do not discontinue other adjunct treatments
    - Continue with strengthening, stretching, and balance training as recommended for the client
  - Although ROM exercises may not result in improved ROM or spasticity for this population, they still have a place as an adjunct treatment
    - Joint lubrication, position changes, and prevention of muscle cramping, especially in non-ambulatory children
References


References


References


Any Questions?