Efficacy and Effectiveness of Adaptive Seating on Sitting Posture and Postural Control in Children with Cerebral Palsy

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Outline of Presentation

- Purpose
- Definitions
- Background
- Research Question
- Methodology
- Overall Results
- Study Results & Discussion
- Limitations
- Clinical Implications
- Conclusions
- Future Directions
Purpose

To examine the current literature to determine the effectiveness and efficacy of adaptive seating on sitting posture and postural control in children with cerebral palsy (CP).
Definitions

- **Adaptive seating**
  - Any modifications to seating devices with the purpose of improving sitting posture and/or postural control in mobility-impaired individuals\(^1\)

- **Posture**
  - A position of the limbs or the body as a whole\(^2,3\)

- **Postural control**
  - The ability to control the body’s position in space to obtain stability and orientation\(^2,3\)
BACKGROUND
Cerebral Palsy

- **Cerebral palsy**
  - A broad term used to describe a group of non-progressive disorders of posture and movement\(^4\)

- **Incidence**
  - 1 in 500 children in Canada\(^5\)

- **Causes**
  - Multi-factorial
  - Attributed to factors during fetal or infant brain development\(^4\)
Cerebral Palsy

● **Clinical features**
  ● Decreased muscle strength
  ● Abnormal muscle tone
  ● Inability to maintain postural control
  ● Abnormal sensation, cognition, communication and/or behaviour

● **Classification**
  ● Severity
  ● Motor disorder
  ● Secondary motor impairments

www.healthofchildren.com/C/Cerebral-Palsy.html
Interventions

- **Postural control interventions**
  - Balance training protocols/devices
  - Ankle foot orthoses
  - Neurodevelopmental treatment
  - Whole-body Lycra® garments
  - Adaptive seating

http://www.theratogs.com
Previous Reviews

- Roxborough\textsuperscript{6} (1995) – 8 studies
  - 3 positive results
    - pulmonary function
    - active trunk extension
    - performance on the Bayley Mental Scale

- Harris and Roxborough\textsuperscript{7} (2005) – 12 studies
  - 7 positive results for postural outcomes
Why is the ICF important for the field of CP?

- Promotes a holistic approach to treatment
- Educates family about the importance of relating function with socialization
Primary Question

What is the effect of adaptive seating on sitting posture and postural control in children between 0 to 20 years of age, who are non-ambulatory with varying types and severity of CP?
Secondary Question

What is the effect of improved sitting posture and/or postural control on participation and functional performance of activities in children with CP?
Inclusion Criteria

- **(P)** Children with CP between 0 and 20 years of age
- **(I)** Adaptive seating
- **(C)** N/A
- **(O)** Sitting posture and/or postural control

Search Strategy

Exclusion Criteria

- **(P)** Children had co-morbidities
- **(I)** Co-interventions or non-seating related adaptive devices
- **(O)** Standing postural control
- A survey, anecdote, letter, or comment
Search Strategy

1. MEDLINE
2. CINAHL
3. EMBASE
4. PUBMED
5. Database of Reviews of Effectiveness (DARE)
6. The Physiotherapy Evidence Database (PEDro)
7. OT Seeker
8. Cochrane Controlled Trials Register
9. Cochrane Database of Systematic Reviews
10. Web of Science
11. Dissertation abstracts
12. Education Resources Information Centre (ERIC)
Key Terms

- Child
- Children
- Cerebral palsy
- Adaptive seating
- Assistive device
- Orthoses
- Positioning
- Seating
- Wheelchair
- Chair
- Infant equipment
- Posture
- Body posture
- Postural control
- Postural dysfunction
- Sitting posture
Search Strategy

Grey Literature
- Reference lists
- Contacting experts in the field

- Journal of Pediatric Orthopedics
- Pediatric Physical Therapy
- Developmental Medicine and Child Neurology
Data Extraction

Our data extraction form included:

- Study designs
- Sample size
- Participant characteristics
- Interventions
- Outcome Measures
- Results
- Conclusions
- Relevant notes
Quality Assessment

Assessment Tools

- Group designs:
  - AACPDAM Quality Assessment Scale
- Single subject designs:
  - The Quality, Rigor, or Evaluative Criteria

Description

- 7-item scales
- Scores are interpreted as: strong (6 or 7), moderate (4 or 5), or weak (3 or less)
# Sackett’s Level of Evidence for Group Design

<table>
<thead>
<tr>
<th>Level</th>
<th>Evidence Type</th>
</tr>
</thead>
</table>
| I     | Systematic review of randomized controlled trials (RCTs)  
Large RCT (with narrow confidence intervals) (n > 100) |
| II    | Smaller RCTs (with wider confidence intervals) (n < 100)  
Systematic reviews of cohort studies  
“Outcomes research” |
| III   | Cohort studies (concurrent control group)  
Systematic reviews of case control studies |
| IV    | Case series  
Cohort study without concurrent control group  
Case-control study |
| V     | Expert opinion  
Case study or report  
Bench research  
Expert opinion based on theory or physiologic research  
Common sense/anecdotes |
# AACPDM Level of Evidence for Single Subject Design

<table>
<thead>
<tr>
<th>Level</th>
<th>Design Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>N-of-1 randomized controlled trial</td>
</tr>
</tbody>
</table>
| II    | ABABA design  
       | Alternating treatments design  
       | Multiple baseline designs (concurrent or non-concurrent; across subjects, settings, or behaviours) |
| III   | ABA design |
| IV    | AB design (with replication on ≥ subject) |
| V     | AB design (with 1 subject only) |
Flow Chart

**TITLE SCREENING**
Citations excluded after title screening (n = 325)

**ABSTRACT SCREENING**
Studies excluded after abstract screening (n = 126)

**FULL TEXT REVIEW**
Studies excluded after full text review (n = 6)
- Qualitative reviews (n=2)
- Upper limb function (n=1)
- Adult CP subjects (n=1)
- No data for extraction (n=2)

Potentially relevant citations identified through electronic and hand searches (n = 468)
Abstracts retrieved for review (n = 143)
Full articles retrieved for review (n = 19)
Relevant studies included in systematic review (n = 13)
OVERALL RESULTS
<table>
<thead>
<tr>
<th>Study Characteristics</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Design</td>
<td>10 group designs, 1 single subject design, 2 case studies</td>
</tr>
<tr>
<td>Methodological Quality</td>
<td>0 to 7 (median: 4)</td>
</tr>
<tr>
<td>Level of Evidence</td>
<td>II to V (median: IV)</td>
</tr>
</tbody>
</table>
## Participant Characteristics

<p>| | |</p>
<table>
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<tbody>
<tr>
<td><strong>No. Subjects</strong></td>
<td>2 to 23 (total: 152)</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>12 mos to 20.8 yrs</td>
</tr>
<tr>
<td><strong>Motor Impairments</strong></td>
<td>Diplegia (n=7), triplegia (n=2), tetraplegia (n=6)</td>
</tr>
<tr>
<td><strong>Motor Disorders</strong></td>
<td>Spastic (n=12), dystonia (n=2), athetosis(n=2)</td>
</tr>
<tr>
<td><strong>Severity of CP</strong></td>
<td>Mild, moderate, severe</td>
</tr>
</tbody>
</table>
Interventions

- Saddle seats (n=3)
- Seat/backrest inclinations (n=4)
- Seat inserts (n=2)
- External supports (n=1)
- Modular seating system (n=4)
<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Studies</th>
<th>ICF Model</th>
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<tbody>
<tr>
<td>Sitting posture</td>
<td>6</td>
<td>Body structure</td>
</tr>
<tr>
<td>Sitting postural control</td>
<td>11</td>
<td>Body structure and function</td>
</tr>
<tr>
<td>Upper limb function</td>
<td>4</td>
<td>Activity</td>
</tr>
<tr>
<td>Mobility</td>
<td>1</td>
<td>Activity</td>
</tr>
<tr>
<td>Performance of ADLs</td>
<td>1</td>
<td>Activity</td>
</tr>
<tr>
<td>Social skills</td>
<td>2</td>
<td>Participation</td>
</tr>
</tbody>
</table>
STUDY RESULTS & DISCUSSION
Overview

- **Body Structure and Function**
  - Interventions:
    - A) Saddle Seating
    - B) Seat/Backrest Positional Angles
    - C) Seat Inserts
    - D) External Supports
    - E) Modular Seating Systems

- **Activity and Participation**
  - Outcomes:
    - A) Upper Extremity Function
    - B) Mobility
    - C) Social Skills & ADLs
## Grades of Recommendations

<table>
<thead>
<tr>
<th>Grade</th>
<th>Level of Study</th>
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<tbody>
<tr>
<td>A</td>
<td>Level 1 studies</td>
</tr>
<tr>
<td>B</td>
<td>Level 2 or 3 studies</td>
</tr>
<tr>
<td>C</td>
<td>Level 4 studies</td>
</tr>
<tr>
<td>D</td>
<td>Level 5 studies</td>
</tr>
</tbody>
</table>
Body Structure & Function

Sitting Posture & Postural Control
Saddle-position

- Saddle-shaped seat
  - Maintains **abduction** and **outward rotation** of the **hips**
  - Incorporates a **forward slope** to facilitate anterior rotation of the pelvis
  - Encourages a **midline posture**
  - Increases **dynamic and equal weight bearing** through the lower extremities
Saddle Position

Pope et al. (1994)
Saddle Position

- Pope et al.\(^8\) (1994)
  - **Description:**
    - Level IV evidence; 4/7 quality
  - **Findings:**
    - variable results - no to little improvement in sitting posture and postural control
  - **Major limitations:**
    - Small sample size (n=9)
    - Lack of control of confounding variables eg. Environment
    - Poor adherence to intervention
Saddle Position

Reid$^9$ (1996)

- **Description:**
  - Level IV evidence; 4/7 quality

- **Findings:**
  - Significant decrease in abnormal postural responses = improved sitting postural control
  - Significant increase in spinal extension = improved sitting posture

- **Major limitations:**
  - Did not control for postural cueing
  - Did not operationally define mild and moderate CP
Saddle Position

Stewart & McQuilton\textsuperscript{10} (1987)

\begin{itemize}
  \item \textbf{Description:}
    \begin{itemize}
      \item Level V evidence; 0/7 quality
    \end{itemize}
  \item \textbf{Findings:}
    \begin{itemize}
      \item Qualitative observation showed improved sitting postural control
    \end{itemize}
  \item \textbf{Major limitations:}
    \begin{itemize}
      \item No reports of inter or intrarater reliability
      \item Lack of details re: methods and intervention
    \end{itemize}
\end{itemize}
### Saddle Position

<table>
<thead>
<tr>
<th>Author</th>
<th>Level of evidence</th>
<th>Quality</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pope(^8)</td>
<td>IV</td>
<td>4</td>
<td>Variable</td>
</tr>
<tr>
<td>Reid(^9)</td>
<td>IV</td>
<td>4</td>
<td>Improved</td>
</tr>
<tr>
<td>Stewart(^{10})</td>
<td>V</td>
<td>0</td>
<td>Improved</td>
</tr>
</tbody>
</table>
Saddle Position

Overall recommendations:
- **Grade C**: mixed evidence
- **Grade D**: one study lends support
Anteriorly- vs. Posteriorly tipped bases?

Anteriorly tipped seat bases:
- more upright and stable sitting posture
- reduce kyphosis
- maintain lumbar lordosis
- decrease posterior pelvic rotation
- shift the centre of gravity forward

Posteriorly tipped seat bases:
- reduce EMG activity of hyperactive muscles
- facilitates the development of functional movement in sitting
Positional Angles

- Sochaniwskyj\textsuperscript{11} (1991)
  - **Description:**
    - Level III; 3/7 quality
  - **Findings:**
    - 10° anterior tilt:
      - significantly increased back extension
    - 15° anterior tilt:
      - significantly decreased sitting postural control
      - greatest EMG activity of erector spinae muscles
  - **Major limitations:**
    - Non-equivalent control group
    - Poor construct validity
Positional Angles

- McClenaghan et al.\textsuperscript{12} (1992)
  - Description:
    - Level III; 5/7 quality
  - Findings:
    - Quiet sitting: 5° posterior tilt improved lower limb stability; 5° anterior tilt decreased head stability
    - Active sitting: no differences
  - Major limitations:
    - High inter-subject variability
    - No interrater reliability reported
Miedaner\textsuperscript{13} (1990)

- **Description:**
  - Level III; 2/7 quality

- **Findings:**
  - 20° forward tilted bench improved trunk extension in sitting

- **Major limitations:**
  - No interrater reliability reported
Positional Angles

- Nwaobi\textsuperscript{14} (1983)
  - **Description:**
    - Level V; 4/7 quality
  - **Findings:**
    - Lowest EMG muscle activity when back rest at 90\(^\circ\) and seat inclined at 0\(^\circ\)
  - **Major limitations:**
    - Only looked at low back extensors
    - Only recorded EMG muscle activity for 60 seconds
<table>
<thead>
<tr>
<th>Author</th>
<th>Level of evidence</th>
<th>Quality</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sochaniwskyj\textsuperscript{11}</td>
<td>III</td>
<td>3</td>
<td>Improved with 10° anterior tilt</td>
</tr>
<tr>
<td>McClenaghan\textsuperscript{12}</td>
<td>III</td>
<td>5</td>
<td>Improved with 5° posterior tilt</td>
</tr>
<tr>
<td>Miedaner\textsuperscript{13}</td>
<td>II</td>
<td>2</td>
<td>Improved with anterior tilt</td>
</tr>
<tr>
<td>Nwaobi\textsuperscript{14}</td>
<td>V</td>
<td>4</td>
<td>Improved with neutral position</td>
</tr>
</tbody>
</table>
Overall recommendations:

- **Grade B**: mixed: two studies supported anterior tilt; one study supported posterior tilt
- **Grade D**: one study supported neutral position
Seat Inserts

- Added to a child’s adaptive seating device to improve postural control
  - Contoured foam seating (CFS)
  - Biofeedback
Seat Inserts

- Washington et al.\textsuperscript{15} (2002)

  **Description:**
  - Level II; 7/7 quality
  - Contoured foam seating that is custom molded

  **Findings:**
  - Significant increase in time spent in midline = improved sitting postural control
  - Parental report of improved postural alignment

  **Major limitations:**
  - Small convenience sample (n=2)
  - Clinician who made CFS had 12 years of experience
Seat Inserts

- Bertoti (1988)
  - Description:
    - Level IV; 3/7 quality
    - Biofeedback seat insert
  - Findings:
    - Subjective report of improved sitting posture
  - Major limitations:
    - Subjects were children with “normal intelligence”
    - Amount of use needed to optimize gains, feasibility of compliance, long term effects
# Seat Inserts

<table>
<thead>
<tr>
<th>Author</th>
<th>Level of evidence</th>
<th>Quality</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington$^{15}$</td>
<td>II</td>
<td>7</td>
<td>Improved</td>
</tr>
<tr>
<td>Bertoti$^{16}$</td>
<td>IV</td>
<td>3</td>
<td>Improved</td>
</tr>
</tbody>
</table>
Seat Inserts

Overall recommendations:
- **Grade B**: one study supports use of CFS
- **Grade C**: one study supports use of biofeedback
External Supports

- Lateral supports arranged in a 3-point force system
- 2 parallel forces opposed by a single force acting in the opposite direction
External Supports

Holmes et al.\textsuperscript{17} (2003)

- **Description:**
  - Level IV; 5/7 quality
  - 3-point lateral supports system

- **Findings:**
  - Significantly improved scoliosis = improved sitting posture

- **Major limitations:**
  - only measured in 2-D, but scoliosis is 3-D
  - ?? Long term effects, adherence
Overall recommendations:

- **Grade C**: one study supports 3 point lateral support force system
Modular Seating Systems

- Combination of positional adjustments and orthoses
- Allows for a functional sitting position
Modular Seating Systems

- “Maxit” or “Real” Chair
  - Symmetrically weight bearing on ischial tuberosities
  - Line of gravity of the upper body anterior to axis of rotation at the ischial tuberosities
  - Hips fixated with a belt under the seat
  - Legs separated by an abduction orthosis
  - Seat base either horizontal or anteriorly tipped
Myhr & von Wendt (1990)

**Description:**
- Level V; 2/7 quality
- Modular seating system

**Findings:**
- Longest duration of head control & least number of pathological movements = improved postural control

**Major limitations**
- Small sample size (n=2)
- Not standardized intervention
- Poor construct validity
Modular Seating Systems

- Myhr & von Wendt\textsuperscript{19} (1991)
  - **Description:**
    - Level IV; 6/7 quality
    - “Maxit” or “Real” Chair
  - **Findings:**
    - Significantly improved overall sitting postural control
  - **Major limitations:**
    - Non standardized intervention
    - Sitting Assessment Scale – no reports of validity or reliability
    - Use of Spearman correlation coefficient
Modular Seating Systems

- **Myhr et al.** (1995)
  - **Description:**
    - Level IV; 6/7 quality
    - 5 yr follow-up study
  - **Findings:**
    - 8 of 10 children:
      - maintained functional sitting position
      - significant improvement in sitting postural control
    - 2 children:
      - deteriorated and trunk control worsened
  - **Major limitations:**
    - Same methods a/a, thus limitations are similar
Ther Adapt Posture Chair

Consists of adjustable:
- Seat height
- Kneepads
- Lumbar support

Used to obtain a stabilized sitting posture
Modular Seating Systems

- **Miedaner** (1990)
  - **Description:**
    - Level III; 2/7 quality
  - **Findings:**
    - Ther Adapt Posture Chair improved trunk extension in sitting
  - **Major limitations:**
    - Intervention was not specified and standardized
<table>
<thead>
<tr>
<th>Author</th>
<th>Level of evidence</th>
<th>Quality</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myhr (1990)</td>
<td>V</td>
<td>2</td>
<td>Improved</td>
</tr>
<tr>
<td>Myhr (1991)</td>
<td>IV</td>
<td>6</td>
<td>Improved</td>
</tr>
<tr>
<td>Myhr (1995)</td>
<td>IV</td>
<td>6</td>
<td>Improved</td>
</tr>
<tr>
<td>Miedaner</td>
<td>II</td>
<td>2</td>
<td>Improved</td>
</tr>
</tbody>
</table>
Modular Seating Systems

Overall recommendations:

- **Grade B**: one study support the use of Ther Adapt Posture Chair
- **Grade C**: one study lends support to use of the "Maxit" or "Real" chair; one study reported long term improvements
- **Grade D**: one study supports a modular seating system
Activity and Participation

Upper limb function, Mobility, Social Skills and Performance of ADLs
Upper Limb Function

- **Saddle seat** (Pope et al.\(^8\), Reid\(^9\))
  - No significant impact on improving:
    - fine motor
    - dexterity
    - upper limb function

www.umich.edu/~urecord/9899/Mar15_99/10.htm
Upper Limb Function

- **Seat Positional Angles** *(McClenaghan et al.\textsuperscript{12})*
  - 5° anterior tilt:
    - significant increase in thumb-press performance
  - 5° posterior tilt:
    - Reduction in linear tapping performance

- **CFS** *(Washington et al.\textsuperscript{15})*
  - No clear effects
Overall recommendations

More research is needed to examine the link between improved posture and postural control on increased upper limb ability.

http://www.kines.umich.edu/research/chmr/images/P4040002a.jpg
Mobility

- **Saddle seat** (Pope et al.\textsuperscript{8})
  - Overall increase in mobility

- **Overall recommendations**
  - More research is needed to examine the activity component of the ICF

http://www.uwmc.net/community/impact/images/Sierra-for-Web.jpg
Social Skills & Performance of ADLs

- **CFS** *(Washington et al., 15)*
  - Subjective reports of improved:
    - social interactions
    - functional independence
    - feeding ability
    - functional performance
Overall recommendations

- More objective measurements are needed to capture the magnitude of change in these outcomes
Limitations of Current Review

- Heterogenous population
  - Difficult to compare in terms of severity, age, type of CP and motor impairment

- No standardization of outcome measures

- Low-level of evidence (Level II to V)

- Publication bias

- Lack of current research

- English language
Adaptive seating should be individualized to meet the needs of each child.

Therapists should be patient as developing an appropriate seating device requires multiple adjustments over a series of visits.

Appropriate use of adaptive seating can lead to improvements at the **body structure/function**, **activity**, and **participation** components of the ICF model.
Conclusions

- No single intervention has been shown to be more effective than others in improving sitting posture and/or postural control.

- Limited evidence to suggest whether improved sitting posture and/or postural control will lead to improved functional abilities.

- More research is needed.
Future Directions

- Studies with stronger levels of evidence and rigorous research designs
- Use of validated classification systems to describe the motor function (e.g. Gross Motor Function Classification Scale)
- Standardized outcome measures for postural control
- Studies that examine the link between postural control to functional skills and level of participation.
Acknowledgements

- Lori Roxborough
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- Marie Westby
- Charlotte Beck
- Steve Ryan
- Tanja Mason
- Janice Evans
Thank you! Any questions?
References

Definition of ICF Components (ref):

- **Body Functions**: physiological and psychological functions of body systems
- **Body Structures**: anatomical parts of the body such as organs, limbs and their components
- **Activity**: the execution of a task or action by an individual.
- **Participation**: involvement in a life situation.
- **Environmental Factors**: physical, social, cultural, institutional or attitudinal in nature
- **Personal Factors**: Gender, age, education and lifestyle
<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Measures</th>
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<tbody>
<tr>
<td>Sitting posture</td>
<td>Subjective reports</td>
</tr>
<tr>
<td></td>
<td>Trunk, hip, and knee ROM</td>
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<td></td>
<td>Spinous process angle measurements</td>
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<tr>
<td>Sitting postural control</td>
<td>Subjective reports</td>
</tr>
<tr>
<td></td>
<td>Displacement of head, trunk, and lower limbs</td>
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<td>Number of pathological movements</td>
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<td></td>
<td>EMG activity of back extensors</td>
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<td>Sitting Assessment Scale</td>
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<td>Level of Sitting Ability Scale</td>
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<td>The Sitting Assessment Scale for Children with Neuromotor Dysfunction</td>
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<td>Outcomes</td>
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<td>Performance in fine motor and dexterity tasks</td>
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<td>5 point scale</td>
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<td>Social skills and performance of ADLs</td>
<td>Subjective reports</td>
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