SUMMARY OF RESEARCH STUDIES

Cerebral Palsy Clinical Phenomena and Impact of Dynamic Seating

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The following table is a summary of research studies related to clinical phenomena observed in people with cerebral palsy (CP) using wheelchair seating and mobility (WSM) and research studies related to the impact of dynamic seating (DS) on each of these phenomenon.

The first column lists common clinical phenomena seen in people with cerebral palsy. The second column summarizes research that supports the presence of each clinical phenomenon in people with cerebral palsy. The third column summarizes research related to dynamic seating and its impact on each clinical phenomenon.

Clinical Phenomenon	Research that supports this is an issue in CP	Research about DS and this issue
Extension / Spasticity	1. Spasticity increases with resistance, such as client forces exerted against a non-yielding surface (Bar-On, et al., 2018). 2. Clients with increased extension were able to exert up to 200% of their body weight against the back support and up to 600% of their body weight against the foot supports during extension (Samaneein, et al., 2013).	1. Dynamic Seating decreased extensor thrust (Cimolin, et al., 2009). 2. Dynamic Seating decreased extension patterns (Lange, 2021).
Dystonia	1. Dystonia can lead to pain and discomfort and impact function (Penner, et al., 2013).	1. Hypothesis proposed that the use of whole-body dynamic seating can improve comfort, activity, participation, and quality of life in young children with dystonic cerebral palsy (Gimeno and Adlam, 2020). This requires more research. 2. Reduced large upper extremity movement and increased smoothness of movement observed in research participants who had the diagnoses of cerebral palsy and dystonia (Cimolin, et al., 2009).
Pain	1. Four out of six teens with cerebral palsy (GMFCS V) reported pain (Ridilla, et al., 2024). 2. One study of children with cerebral palsy found that nearly 55% of participants reported pain (Penner, et al, 2013) and another study found that 75% of children with cerebral palsy were in pain (Novak, et al., 2012). 3. Comfort is a high priority for families (Gimeno, et al., 2013). 4. Extension forces can lead to pain and, as a result, decrease sitting tolerance (Cimolin, et al., 2009; Incoronato, 2007). 5. Of people with CP, 75% experience chronic pain (CPARF.org). 6. Adults with CP are more likely to experience joint pain compared to non-disabled adults (43.6% vs. 28.0%) (Peterson, et al., 2015). 7. Children with dystonia report pain as a common concern (De Knegt, et al., 2013; Gimeno, et al., 2013; Penner, et al., 2013). 8. Pain may lead to decreased function and mobility (Haak, et al., 2009). 9. One study concluded that over half of the participants who had spastic CP reported problematic pain. The participants were individuals with CP GMFCS levels IV and V who used power wheelchairs (Frank, et al., 2017).	1. The Ridilla, et al. study (2024) indicated an increase in self-relief of pressure after prolonged seating in a response to increased pain. 2. Frank, et al. (2012) found that most power wheelchair users in their study experienced pain and that one strategy that reduced pain was changing position. 3. Movement has been shown to decrease pain in wheelchair users (Lyons, et al., 2017; Frank & DeSouza, 2017). 4. Incoronato (2007) found a reduction in pain with use of a specific dynamic seating system in a retrospective study.

Clinical Phenomenon	Research that supports this is an issue in CP	Research about DS and this issue
Arthritis	1. Adults with CP are more likely to experience arthritis compared to non-disabled adults (31.4% vs. 17.4%, Peterson, et al., 2015) (Whitney, et al., 2018). 2. Arthritis may lead to decreased function and mobility (Haak, et al., 2009).	These studies could form the basis for future research to determine if dynamic seating could diffuse extensor forces to specifically lessen forces occurring in the joints.
Injury (from extensor forces, often from forceful contact with equipment or with damaged equipment)	1. The forces from extension on the client's body can lead to injury (Hong, 2006, Lange, 2021).	1. Further injuries were prevented in a client using dynamic seating who had a history of injuries secondary to extreme extension forces (Lange, 2021).
Shear forces (from client moving in relation to seating support surfaces)	1. Cimolin et al. (2009) used quantitative movement analysis to compare movement during extensor thrust using a dynamic back support and using a rigid back support and found increased vertical trunk movement (shear) during extension with the rigid back support.	1. Cimolin et al. (2009) used quantitative movement analysis to compare movement during extensor thrust using a dynamic back support and using a rigid back support and found decreased vertical trunk movement (shear) during extension with the dynamic back support. 2. Dynamic Seating allows movement while maintaining contact with the support surfaces, providing stability, and reducing shear forces (Hahn, 2009; Cimolin, et al, 2009; Chen, et al., 2018).
Equipment Breakage (secondary to strong sustained and/or intermittent client forces)	1. The forces from extension on a static wheelchair seat and frame can be so strong as to cause damage to equipment (Hong, 2006). 2. Breakage frequently occurs at the foot supports, leg support hangers, back support mounting hardware, and head support hardware (Hahn, 2009). 3. Continuous rocking, as well as forceful rocking, can lead to damage of the wheelchair seating system and frame (Incoronato, 2007).	1. Dynamic seating is designed to absorb extreme forces, which in turn, protects the wheelchair seating and frame from wear and tear and even breakage (Incoronato, 2007). 2. A single subject using dynamic seating experienced no further equipment breakage once receiving this intervention, despite a long history of equipment breakage (Lange, 2021).
Lack of movement (secondary to degree of postural support required within a seating system)	1. Many people using wheelchair seating and mobility cannot move their bodies significantly in relation to the seating system. This may be due to motor limitations or the postural supports themselves (Strobl, et al., 2013).	1. Movement can calm (reduce agitation), arouse (increase alertness), strengthen muscles, enhance visual control, and provide comfort, as well as improve voluntary functional movements (Chen, 2018; Phillips, 2017) by varying our position. 2. Maladaptive behaviors may be reduced in response to movement (Pfeiffer, et al., 2008). 3. Rollo, et al. (2017) reviewed 5 studies and found that classroom based dynamic seating improved attention. 4. Self-directed movement increases brain derived neurotrophic factor (BDNF) which enhances brain recovery at the structural and chemical level and encourages dendrite and axon development (Phillips, et al., 2017). *Dynamic Seating may, through self-directed movement of the dynamic components, impact brain recovery, development, and function.*
Decreased postural control, stability, and function	1. Motor development plateaus for children with CP as early as 3 years of age with one out of three children unable to gain adequate trunk control for stable, independent sitting (Beckung, et al., 2007; Rosenbaum, et al., 2002). The estimated limit of development decreased as severity of impairment increased (Rosenbaum, et al., 2002).	1. Dynamic Seating allows movement while maintaining contact with the support surfaces, providing stability, and reducing shear forces (Chen, et al., 2018; Hahn, 2009; Cimolin, et al, 2009). 2. Adlam, et al. (2014) found increased head control and increased symmetry in posture using a dynamic seating system. 3.Incoronato (2007) noted improved posture in their study. 4. McNamara & Casey (2007) found improved overall positioning, including reduced sacral sitting (related to seat inclination). 5. Adlam (2015) found increased function with use of a dynamic seat in one study and in another (2014) one subject was able to access a switch when using dynamic seating. 6. Incoronato (2007) found improvement of motor control of the upper extremities, trunk, and head. 7. Dalton, (2014) found increased head and arm control with a simulated dynamic foot support. 8. Cimolin, et al. (2009) noted increased smoothness of movement. 9. Movement can increase vestibular and proprioceptive stimulation which can improve stability (Chen, et al., 2018). 10. Movement against resistance has been demonstrated to increase strength in people with increased muscle tone (McBurney, et al., 2003) without an increase in spasticity (Fowler, et al., 2001).

Clinical Phenomenon	Research that supports this is an issue in CP	Research about DS and this issue
Range of motion losses (often secondary to prolonged time in a position, such as sitting in a wheelchair)	1. Range of motion may decrease secondary to a prolonged seated position (Strobl, et al., 2013).	1. Increased range of motion and movement was found when using dynamic seating (Adlam, et al., 2014; Cimolin, et al., 2009; Hahn, et al., 2009; Incoronato, 2007).
GI issues (including reflux, digestion, and constipation)	1. Children with CP are prone to digestive issues such as upset stomach, vomiting, bloating, and constipation (Sullivan & Andrew, 2017).	1. Dynamic seating improves digestion (Incoronato, 2007).
Decreased vocalization	1. Speech Problems affect more than half of children with CP (based in Sweden, Nordberg, et al., 2013).	1. Dynamic seating improves vocalization (Adlam, et al., 2014).
Decreased circulation, often secondary to prolonged sitting	1. Patrangenaru (2006) noted that static seating can lead to circulation-related issues.	1. Increasing movement improves circulation and has health benefits (Myers, et al., 2021).
Decreased social engagement and participation	1. Children with CP have less participation and enjoyment of social and recreational activities compared to typically developing children (Chiarello, et al, 2014).	1. Adlam, et al. (2015) found increased social engagement with dynamic seating intervention.

Conclusion

More research is needed to provide further, and more recent, support of dynamic seating intervention. Initially developed to prevent equipment damage, dynamic seating has been shown to provide a broad range of clinical benefits for people with cerebral palsy who utilize wheelchair seating and mobility.

Abbreviations

CP	Cerebral Palsy
GMFCS	Gross Motor Functional Classification System
MWC	Manual Wheelchair
PWC	Power Wheelchair
WSM	Wheelchair Seating and Mobility

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