The following are results of a literature review on Dynamic Wheelchair Seating. This term is used in multiple contexts. Some articles refer to dynamic seating but are addressing changes to the seated posture during manual wheelchair propulsion. Other articles refer to dynamic surfaces or cushions that "actively redistribute pressure on the body surfaces." Some articles refer to a seat's "dynamic stiffness".

This review explores literature in the context of dynamic wheelchair seating where a part of the wheelchair or wheelchair seating system moves in response to client movement. Dynamic seating is defined as movement which occurs within the seating system and/or wheelchair frame in response to intentional or unintentional force generated by the client. Dynamic components absorb force. When client force ceases, the stored energy is returned through the dynamic component, which in turn assists the client back to a starting position.

This Literature Review is categorized into the following sections:

Peer Reviewed Publications

Lange, M. L. (2022). Dynamic Seating: providing movement for clinical benefit. In PMG Journal. Posture & Mobility Group. Online.
https://www.pmguk.co.uk/journals/dynamic-seating-providing-movement-for-clinical-benefit

Lange, M. L. (2021). Clinical changes as a result of dynamic seating in a young adult with cerebral palsy. Disability and Rehabilitation: Assistive Technology, 1-6. DOI: 10.1080/17483107.2021.1984593

Lange, M. L., Crane, B., Diamond, F. J., Eason, S., Pedersen, J. P., & Peek, G. (2021). RESNA position on the application of dynamic seating. Assistive Technology. DOI: 10.1080/10400435.2021.1979383

Geers, Prinsen, van der Pijl, et. Al (2021). Head support in wheelchairs: state of the art and beyond. Disability and Rehabilitation: Assistive Technology.
DOI: 10.1080/17483107.2021.1892840
Includes dynamic head supports.

Digiovine, C. P., Berner, T. F., Kim, D. J., Schmeler, M., Cooper, R., & Cooper, R. A. (2021). Wheelchairs and seating systems. In Braddom's Physical Medicine and Rehabilitation (pp. 261-290). Elsevier.
https://doi.org/10.1016/B978-0-323-62539-5.00014-X.
Includes dynamic seating.

Castellucci, H. I., Viviani, C., Arezes, P., Molenbroek, J. F., Martínez, M., & Aparici, V. (2021). Application of mismatch equations in dynamic seating designs. Applied Ergonomics, 90, 103273.
https://doi.org/10.1016/j.apergo.2020.103273.
Designs challenges to match client dimensions and achieve responsive movement.

Mahmood MN, Tabasi A, Kingma I, et al. A novel passive neck orthosis for patients with degenerative muscle diseases: development & evaluation. J Electromyogr Kinesiol. 2021;57:102515.
https://doi.org/10.1016/j.jelekin.2021.102515
Development of a neck orthosis to provide support during head movement for people with muscle weakness.

Wilson, P. E., Lange, M. (2014, updated 2021). Seating Evaluation and Wheelchair Prescription. http://emedicine.medscape.com/article/318092-overview.
Seating and Wheeled Mobility clinical applications, including Dynamic Seating

Lange, M., Crane, B., Diamond, F., Eason, S., Pedersen, J., & Peek, G. (2020). RESNA Position on the Application of Dynamic Seating. Rehabilitation Engineering & Assistive Technology Society of North America. https://www.resna.org/Portals/0/RESNA%20Position%20on%20the%20Application%20of%20Dynamic%20Seating.pdf.

Gimeno, H., & Adlam, T. (2020, March). Protocol: Using Single-Case Experimental Design to Evaluate Whole-Body Dynamic Seating on Activity, Participation, and Quality of Life in Dystonic Cerebral Palsy. In Healthcare (Vol. 8, No. 1, p. 11). Multidisciplinary Digital Publishing Institute.
https://doi.org/10.3390/healthcare8010011.
"This paper reports a protocol to assess the feasibility and preliminary evidence for the efficacy of dynamic seating to improve functional outcomes for young children with dystonic cerebral palsy (DCP)."

Long, D. (2020). Wheelchair prescription. In Clinical Engineering (pp. 411-429). Academic Press.
https://doi.org/10.1016/B978-0-08-102694-6.00025-5.
Includes dynamic seating.

Howard, J. D., Eggbeer, D., Dorrington, P., Korkees, F., & Tasker, L. H. (2020). Evaluating additive manufacturing for the production of custom head supports: A comparison against a commercial head support under static loading conditions. Proceedings of the Institution of Mechanical Engineers, Part H: Journal of Engineering in Medicine, 234(5), 458-467.
Forces required to damage head support hardware and head support pad.

Togashi N, Shimono T, Nozaki T, et al. Development of Three-Axis Seating Posture Holding Assist Chair and Proposed Variable Compliance Control. Proc - 2019 IEEE Int Conf Mechatronics, ICM 2019 [Internet]. Kanagawa Institute or Industrial Science and Technology, 3-2-1 Sakado, Takatu, Kawasaki, 213-0012, Japan; 2019. p. 455–460. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85067120926&doi=10.1109%2FICMECH.2019.8722874&partnerID=40&md5=463a64ac02126c2d5cf3316786c91676.
Development of a prototype wheelchair with movement at the hips and neck.

Novak, I., Morgan, C., Fahey, M. et al. State of the Evidence Traffic Lights 2019: Systematic Review of Interventions for Preventing and Treating Children with Cerebral Palsy. Curr Neurol Neurosci Rep 20, 3 (2020).
https://doi.org/10.1007/s11910-020-1022-z
"All these interventions have the following features in common: practice of real-life tasks and activities, using self-generated active movements, at a high intensity, where the practice directly targets the achievement of a goal set by the child (or a parent proxy if necessary). The mechanism of action is experience-dependent plasticity [256]. Motivation and attention are vital modulators of neuroplasticity, and successful task-specific practice is rewarding and enjoyable to children, producing spontaneously regular practice"
"In the early years, experts recommend high intensity self-generated active movement to prevent the onset of weakness, disuse and contracture"

Hamzah SR, Izmin NAN, Tardan G, et al. (2019). Design and analysis of adjustable headrest for total body involvement cerebral palsy. Int J Recent Technol Eng. 8:3208–3211. [Google Scholar]
Development of a headrest that includes rotation.

Mattie, J., Aitken-Mundhenk, L., Bicknell, L., Mortenson, W. B., & Borisoff, J. (2019). Exploring the lived experience of people using ultralight wheelchairs with on-the-fly adjustable seating function. Disability and Rehabilitation: Assistive Technology.

https://doi.org/10.1080/17483107.2019.1626920.
Featuring the Elevation dynamic wheelchair.

Whitney, D. G., Hurvitz, E. A., Ryan, J. M., Devlin, M. J., Caird, M. S., French, Z. P., ... & Peterson, M. D. (2018). Noncommunicable disease and multimorbidity in young adults with cerebral palsy. Clinical epidemiology, 10, 511. https://dx.doi.org/10.2147%2FCLEP.S159405.
People with cerebral palsy are much more likely to develop arthritis at a young age in comparison with the rest of the population. Possibly due to excessive forces at joints.

Tagge et al, (2018). "Concussion, microvascular injury, and early tauopathy in young athletes after impact head injury and an impact concussion mouse model," Brain Journal.
https://doi.org/10.1093/brain/awx350.
Repeated impacts, even in the absence of concussion, can lead to brain injury.

Chen, X., Liu, F., Yan, Z., Cheng, S., Liu, X., Li, H., & Li, Z. (2018). Therapeutic effects of sensory input training on motor function rehabilitation after stroke. Medicine,97(48). doi:10.1097/md.0000000000013387
Sensory function has significant effects on voluntary functional movements. Sensory input plays a crucial role in motor function rehabilitation and the combined sensorimotor training modality is more effective than conventional motor-oriented approaches.
Movement can increase vestibular and proprioceptive stimulation opportunities which can, in turn, promote balance, stability and spatial orientation.

Brown, J. E., Thompson, M., & Brizzolara, K. (2018). Head Control Changes After Headpod Use in Children with Poor Head Control: A Feasibility Study. Pediatric Physical Therapy, 30(2), 142-148.
https://doi.org/10.1097/PEP.0000000000000492.
Use of the Head Pod resulted in improved head control.

Bar-On, L., Desloovere, K., & Harlaar, J. (2018). Spasticity Assessment in Cerebral Palsy. In Cerebral Palsy (pp. 1-16). Springer.
http://www.ghrnet.org/index.php/ijnr/article/view/1005
Spasticity increases with resistance, such as extension forces against a non-yielding surface.

Thomas, L., Borisoff, J., & Sparrey, C. J. (2018). Manual wheelchair downhill stability: an analysis of factors affecting tip probability. Journal of neuroengineering and rehabilitation, 15(1), 1-12.
https://jneuroengrehab.biomedcentral.com/articles/10.1186/s12984-018-0450-3.
Featuring the Elevation dynamic wheelchair.

Mattie, J., Wong, A., Leland, D., & Borisoff, J. (2018). End user evaluation of a Kneeling Wheelchair with "on the fly" adjustable seating functions. Disability and Rehabilitation: Assistive Technology.
https://doi.org/10.1080/17483107.2018.1462861.
Featuring a prototype dynamic wheelchair.

Tramontano, M., Medici, A., Iosa, M., Chiariotti, A., Fusillo, G., Manzari, L., & Morelli, D. (2017). The Effect of Vestibular Stimulation on Motor Functions of Children with Cerebral Palsy. Motor Control,21(3), 299-311. doi:10.1123/mc.2015-0089
Study:
Study to assess the efficacy of a vestibular stimulation training in improving motor functions in cerebral palsy.
Results:
A significant improvement was noted after a combination of neurodevelopmental treatment (NDT) and vestibular training.

Phillips, C. (2017). Brain-Derived Neurotrophic Factor, Depression, and Physical Activity: Making the Neuroplastic Connection. Neural Plasticity, 1-17.

doi:10.1155/2017/7260130.
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.

Voss, P., Thomas, M. E., Cisneros-Franco, J. M., & Villers-Sidani, É D. (2017). Dynamic Brains and the Changing Rules of Neuroplasticity: Implications for Learning and Recovery. Frontiers in Psychology,8.
doi:10.3389/fpsyg.2017.01657.
Enriched environments prolong the critical periods of neuroplasticity (experience dependent plasticity), stimulate dendritic growth, and improve neuronal response properties. Sensory stimulation, such as vestibular input from movement, can increase plasticity windows. Sensory deprived environments postpone the onset of critical periods of neuroplasticity and maintain cortical neurons in an immature state.

Furumasu, J. (2017). Consideration when working with the Pediatric Population. In Seating and Wheeled Mobility: a clinical resource guide. Slack, Inc., Thorofare, NJ.
https://www.healio.com/books/health-professions/occupational-therapy/%7B0494f75e-c42b-4f30-96d8-175a3fd90747%7D/seating-and-wheeled-mobility-a-clinical-resource-guide.
This chapter includes clinical applications of Dynamic Seating.

Mattie, J., Borisoff, J., Miller, W. C., & Noureddin, B. (2017). Characterizing the community use of an ultralight wheelchair with “on the fly” adjustable seating functions: A pilot study. PloS one, 12(3), e0173662.
https://doi.org/10.1371/journal.pone.0173662.
Pilot study investigating and characterizing the use of the two adjustable seating functions on the Elevation ultralight dynamic wheelchair during community use.

Inskip, J. A., Ravensbergen, H. R. J., Sahota, I. S., Zawadzki, C., McPhail, L. T., Borisoff, J. F., & Claydon, V. E. (2017). Dynamic wheelchair seating positions impact cardiovascular function after spinal cord injury. PloS one, 12(6), e0180195.
https://doi.org/10.1371/journal.pone.0180195.
Study of the effects of moderate changes in wheelchair position on orthostatic cardiovascular and cerebrovascular reflex control in persons with spinal cord injury using the Elevation ultralight dynamic wheelchair. Lowered seating (rear of seat lower than front) increased blood pressure in those with lesions to the autonomic pathways.

SADR, N. M., Haghgoo, H. A., Samadi, S. A., Rassafiani, M., Bakhshi, E., & Hassanabadi, H. (2017). The impact of dynamic seating on classroom behavior of students with autism spectrum disorder. Iranian journal of child neurology, 11(1), 29.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5329757/.
The study compared the effect of regular classroom chairs, therapy balls, and air cushions on classroom behavior of students with autism. Improved in-seat behavior (86.7%) and on-task behavior (53.3%) with use of therapy ball.

Rollo, S., Smith, S., & Prapavessis, H. (2017). Do you want your students to pay more attention in class? Try Dynamic Seating! Journal of Ergonomics.
https://www.researchgate.net/profile/Scott_Rollo/publication/321276117_Do_You_Want_Your_Students_to_Pay_More_Attention_in_Class_Try_Dynamic_Seating/links/5a1849ac4585155c26a94ceb/Do-You-Want-Your-Students-to-Pay-More-Attention-in-Class-Try-Dynamic-Seating.pdf.
The authors reviewed literature on the use of classroom-based dynamic seating to improve attention. 5 studies were reviewed and the evidence supports improved attention.

Elizabeth A. Lyons, Diana E. Jones, Veronica M. Swallow, Colin Chandler. (2017) An Exploration of Comfort and Discomfort Amongst Children and Young People with Intellectual Disabilities Who Depend on Postural Management Equipment. Journal of Applied Research in Intellectual Disabilities 30:4, pages 727-742.
http://eprints.whiterose.ac.uk/105176/3/Accepted%20Lyons%20et%20al.pdf.
“Positioning discomfort first presents itself as an unconscious desire to change body posture, which

diminishes when the individual is able to initiate a change of posture. The discomfort increases across time and may be associated with one or more factors such as instability, sliding, excessive heat buildup, stiffness, excessive localized soreness or pain, spasticity, or stretch."
Study:
13 children with physical and intellectual disabilities, non-verbal using adaptive seating. Subjective. Results: These children rely on caregivers to note and intervene to relieve their discomfort.
Positioning discomfort diminishes when the wheelchair user can change their position.

Andrew O. Frank & Lorraine H. De Souza (2017) Problematic clinical features of children and adults with cerebral palsy who use electric powered indoor/outdoor wheelchairs: A cross-sectional study, Assistive Technology, 29:2, 68-75.
DOI: 10.1080/10400435.2016.1201873.
Study:
First study to describe a cohort of individuals with CP GMFCS levels IV and V, prescribed a PWC.
CP is now considered a lifespan condition with associated health factors, e.g., musculoskeletal impairments, medical complications, speech impairments, pain, and fatigue (Kembhavi et al.., 2011). It is unclear if these are part of the natural course of CP, a consequence of long-term disability, or unrelated comorbidity.
Clinical features such as spasticity and problematic pain appeared less well managed in adults than in children.
Results:
Of 102 participants, 20 reported problematic pain (over half of those had spastic CP).
"We found nine features of CP, of which eight were reported by Novak et al.., the most frequent being problematic pain (n = 20), hip problems (n = 18), and problematic spasticity (n = 15) (Table 3). Specified causes of problematic pain were spasticity (n = 7), (kypho)scoliosis (n = 6), back pain (n = 5), hip pain (n = 2), back pain, and spasticity (n = 2), no specified cause (n = 4), or more than one of the above. Nine users reported back pain thought to be treatable with standard approaches."
18 required medical management for problematic pain.
Providing movement may reduce pain.

Akkarakittichoke, N., & Janwantanakul, P. (2017). Seat Pressure Distribution Characteristics During 1 Hour Sitting in Office Workers With and Without Chronic Low Back Pain. Safety and health at work, 8(2), 212-219. https://doi.org/10.1016/j.shaw.2016.10.005.
Study of office workers with and without low back pain found that those without low back pain had significantly more frequent postural shifts during prolonged sitting and sat more symmetrically.

Li, C. T., Peng, Y. T., Tseng, Y. T., Chen, Y. N., & Tsai, K. H. (2016). Comparing the effects of different dynamic sitting strategies in wheelchair seating on lumbar-pelvic angle. BMC musculoskeletal disorders, 17(1), 496. https://doi.org/10.1186/s12891-016-1358-3.
Prolonged static sitting in a wheelchair increases risk of lower back pain. The study examined 7 dynamic sitting strategies: lumbar prominent, back reclined, femur upward, lumbar prominent with back reclined, lumbar prominent with femur upward, back reclined with femur upward, lumbar prominent with back reclined. The study analyzed the biomechanical effects of these strategies on lumbar-pelvic angles. Changes in position were made through inflation and deflation of air bags and a power recline. The most beneficial movements were lumbar prominent and lumbar prominent with femur upward in providing movement which may reduce back pain.

Tanoue, H., Mitsuhashi, T., Sako, S., Goto, R., Nakai, T., & Inaba, R. (2016). Effects of a dynamic chair on pelvic mobility, fatigue, and work efficiency during work performed while sitting: a comparison of dynamic sitting and static sitting. Journal of physical therapy science, 28(6), 1759-1763. https://doi.org/10.1589/jpts.28.1759.
Static sitting can lead to lumbar pain, fatigue, and decreased function. Dynamic chair with seat that moves in 3 dimensions affects pelvic mobility. Lumbar fatigue was reduced, and function was increased.

Adlam, T., Johnson, E., Wisbeach, A. and Orpwood, R. (2015). Look at me! A functional approach to dynamic seating for children with dystonia. Developmental Medicine & Child Neurology. Vol 57, pg 27.

doi: 10.1111/dmcn.12780_2.
Abstract from the European Academy of Childhood Disability 27th Annual Meeting. Design of dynamic seat with movement at ankles, hips, knees and back. Seat is instrumented to measure torque and angular displacement. The child demonstrated increased social engagement and function.

Angsupaisal, M., Maathuis, C. G., & Hadders-Algra, M. (2015). Adaptive seating systems in children with severe cerebral palsy across International Classification of Functioning, Disability and Health for Children and Youth version domains: a systematic review. Developmental Medicine & Child Neurology, 57(10), 919-930. https://doi.org/10.1111/dmcn.12762.
A literature review showed that only a small number of high quality research studies addressed adaptive seating systems for children with cerebral palsy. Data suggests that adaptive seating can improve activity and participation. More research is needed.

Bar-On, L., Molenaers, G., Aertbeliën, E., Van Campenhout, A., Feys, H., Nuttin, B., & Desloovere, K. (2015). Spasticity and its contribution to hypertonia in cerebral palsy. BioMed research international, 2015. https://doi.org/10.1155/2015/317047.
Measurement methods for distinction and quantification of hypertonia components. Definitions of pathophysiology of hypertonia and spasticity.

Pynt, J. (2015). Rethinking design parameters in the search for optimal dynamic seating. Journal of bodywork and movement therapies, 19(2), 291-303.
https://www.ncbi.nlm.nih.gov/pubmed/25892386.
Research is needed to determine if new designs that require active sitter involvement fulfill the goals of dynamic seating. Authors suggest new definition of dynamic seating (within office furniture) “Sitting in which the action is provided by the sitter, while the dynamic mechanism of the chair accommodates that action.”

Peterson, M. D., Ryan, J. M., Hurvitz, E. A., & Mahmoudi, E. (2015). Chronic conditions in adults with cerebral palsy. Jama, 314(21), 2303-2305.
doi:10.1001/jama.2015.11025.
Adults with cerebral palsy are more likely to experience joint pain (43.6% vs. 28.0%) and arthritis (31.4% vs. 17.4%) than people without cerebral palsy.

Lin, J. P., Lumsden, D. E., Gimeno, H., & Kaminska, M. (2014). The impact and prognosis for dystonia in childhood including dystonic cerebral palsy: a clinical and demographic tertiary cohort study. Journal of Neurology, Neurosurgery & Psychiatry, 85(11), 1239-1244.
https://jnnp.bmj.com/content/85/11/1239.short?casa_token=c6ZCka_BT_oAAAAA:ew2IECs6Qcfe-HzxxxZSOUBgp-pHTjHWNVUpVKZ4p_pYU5BcHMXkuWsYnryqV2ynLHTXNrnsxQo.
53.7% children with cerebral palsy also demonstrated dystonia.

Levy, A., Kopplin, K., & Gefen, A. (2014). An air-cell-based cushion for pressure ulcer protection remarkably reduces tissue stresses in the seated buttocks with respect to foams: finite element studies. Journal of tissue viability, 23(1), 13-23.
doi: 10.1016/j.jtv.2013.12.005.
An air cushion adapting to changes in position improved pressure relief and decreased tissue stress compared to a foam cushion.

Gimeno, H., Gordon, A., Tustin, K., & Lin, J. P. (2013). Functional priorities in daily life for children and young people with dystonic movement disorders and their families. European journal of Paediatric Neurology, 17(2), 161-168. https://doi.org/10.1016/j.ejpn.2012.07.007.
Comfort is a high priority for families.

Novak, I., Mcintyre, S., Morgan, C., Campbell, L., Dark, L., Morton, N., ... & Goldsmith, S. (2013). A systematic review of interventions for children with cerebral palsy: state of the evidence. Developmental Medicine & Child Neurology, 55(10), 885-910.
https://doi.org/10.1111/dmcn.12246.
Of 64 discrete interventions, 24% have been proven to be effective. There is a gap between research and practice.

Morgan, C., Novak, I., & Badawi, N. (2013). Enriched Environments and Motor Outcomes in Cerebral Palsy: Systematic Review and Meta-analysis. Pediatrics,132(3).
doi:10.1542/peds.2012-3985.
A systematic review was conducted to appraise the effectiveness evidence about Enriched Environments improving the motor outcomes of infants at high risk of cerebral palsy.
Enriched environments Enriched Environments looked promising for children with cerebral palsy.

Crocker, L.D., Heller, W., Warren, S.L., O'Hare, A.J., Infantolino, Z. P., Miller, G. A. (2013). Relationships among cognition, emotion, motivation: implications for intervention and neuroplasticity in psychopathology. Frontiers in Human Neuroscience, 7:261.
https://doi.org/10.3389/fnhum.2013.00261.
Experience-dependent functional and structural changes occur in the brain due to neuroplasticity, including psychological and behavior improvements.

Penner, M., Xie, W. Y., Binepal, N., Switzer, L., & Fehlings, D. (2013). Characteristics of pain in children and youth with cerebral palsy. Pediatrics, 132(2), e407–e413.
doi:10.1542/peds.2013-0224.
Study:
252 participants aged 3 to 19 years across all levels of severity of cerebral palsy.
Results:
54.8% of participants reported some pain, 24.4% of caregivers reported pain that affected level of activity, and 38.7% of physicians reported pain and identified hip dislocation/subluxation, dystonia, and constipation as the most frequent causes.
Pain is prevalent among children with cerebral palsy and is sometimes attributed to dystonia and constipation.

De Knegt, N. C., Pieper, M. J., Lobbezoo, F., Schuengel, C., Evenhuis, H. M., Passchier, J. & Scherder, E. J. (2013). Behavioral pain indicators in people with intellectual disabilities: a systematic review. The Journal of Pain, 14, 885-896.
https://doi.org/10.1016/j.jpain.2013.04.016.
Pain is more common in people with ID and health care professionals must be familiar with pain indicators.

Kuhn D. & Lewis, S. (2013). The Effect of Dynamic Seating on Classroom Behavior and School Performance for Student in a General Education Classroom. Master's Thesis.
https://soundideas.pugetsound.edu/cgi/viewcontent.cgi?article=1079&context=ms_occ_therapy.
Study examined the effect of using FootFidgets and Standing Desks in a fourth grade classroom. Mean attention significantly increased when using both interventions in combination.

Frank, A. O., De Souza, L. H., Frank, J. L., & Neophytou, C. (2012). The pain experiences of powered wheelchair users. Disability and Rehabilitation, 34(9), 770-778.
doi: 10.3109/09638288.2011.619620.
Purpose: To explore the experience of pain and discomfort in users of electric-powered indoor/outdoor wheelchairs (EPIOCs) provided by a National Health Service.
Study:
EPIOC users receiving their chair between February and November 2002 (N = 74) were invited to participate in a telephone questionnaire/interview and 64 (aged 10–81 years) agreed. Both specific and open-ended questions examined the presence of pain/discomfort, its severity, minimizing and aggravating factors, particularly in relation to the EPIOC and its use. Results: Most EPIOC users described experiences of pain with 17% reporting severe pain.

Over half felt their pain was influenced by the wheelchair and few (25%) considered their chair eased their symptoms. The most common strategy for pain relief was taking medication. Other self-help strategies included changing position, exercise and complementary therapies. Respondents emphasized the provision of backrests, armrests, footrests and cushions which might alleviate or exacerbate pain, highlighting the importance of appropriate assessment for this high dependency group.
Results:
Users related pain to their underlying medical condition, their wheelchair or a combination of the two. User feedback is essential to ensure that the EPIOC meets health needs with minimal pain. This becomes more important as the health condition of users changes over time.
Implications for Rehabilitation:
Pain is frequently experienced by users of powered wheelchairs and may be severe.
Clinicians need to distinguish between wheelchair-related pain and pain due to an underlying health condition.
Improved design and additional features to powered wheelchairs should reduce this pain and suffering but at a financial cost.
Most power wheelchair users experienced pain and over half believed this pain was related to the wheelchair itself. One strategy that improved pain was changing position.

Van Der Slot, W. M., Nieuwenhuijsen, C., Van Den Berg-Emons, R., Bergen, M., Hilberink, S., Stam, H., & Roebroecks, M. (2012). Chronic Pain, fatigue, and depressive symptoms in adults with spastic bilateral cerebral palsy. Developmental Medicine and Child Neurology, 54, 69–70.
doi:10.1111/j.1469-8749.2012.04371.x.
Adults with spastic bilateral cerebral palsy were severely affected by chronic pain, fatigue, and depressive symptoms.

Novak, I., Hines, M., Goldsmith, S., & Barclay, R. (2012). Clinical prognostic messages from a systematic review on cerebral palsy. Pediatrics, 130(5), e1285–e1312.
doi:10.1542/peds.2012-0924.
Study:
Systematic review with meta-analysis of 30 studies on CP, included users with pain requiring further investigation or management.
Results:
Among children with cerebral palsy, 3 in 4 were in pain.
Pain needs to be addressed during wheelchair seating interventions.

O'Sullivan, K., O'Keeffe, M., O'Sullivan, L., O'Sullivan, P., & Dankaerts, W. (2012). The effect of dynamic sitting on the prevention and management of low back pain and low back discomfort: a systematic review. Ergonomics, 55(8), 898-908.
https://www.researchgate.net/publication/224050770_The_effect_of_dynamic_sitting_on_the_prevention_and_management_of_low_back_pain_and_low_back_discomfort_A_systematic_review.
Dynamic sitting was not found to be effective in reducing low back pain or low back discomfort as a stand-alone approach in a typical population using office chairs.

O’Sullivan, K., McCarthy, R., White, A., O’Sullivan, L., & Dankaerts, W. (2012). Lumbar posture and trunk muscle activation during a typing task when sitting on a novel dynamic ergonomic chair. Ergonomics, 55(12), 1586-1595.
https://doi.org/10.1080/00140139.2012.721521.
Sitting on a novel dynamic chair (Back App) resulted in less lumbar flexion and less back muscle activation than sitting on a standard backless office chair during a typing task among pain-free participants. Facilitating lordotic sitting with less muscle activation may reduce the fatigue and discomfort often associated with lordotic sitting postures. Increasing hip extension facilitated lordotic sitting with less muscle activation.

Steenbergen R, Lassooij J, Herder JL. Design of a mobile head support based on a compliant mechanism. J Med Device. 2011;5(2):027518.
Design of a head support which moves with a client who has muscle weakness.

Kembhavi, G., Darrah, J., Payne, K., & Plesuk, D. (2011). Adults with a diagnosis of cerebral palsy: A mapping review of long-term outcomes. Developmental Medicine and Child Neurology, 53(7), 610–614. doi:10.1111/j.1469-8749.2011.03914.x.
https://onlinelibrary.wiley.com/doi/full/10.1111/j.1469-8749.2011.03914.x
"The first article to discuss pain in adults with CP was published in 1999.(23) Since then, the number of articles with a focus on pain has increased. Between 2000 and 2010, 11 studies examined pain as an outcome in adults with CP.(7-9, 17-19, 22, 26, 30-32) Of the 12 studies published since 1999, however, seven have been based on data derived from two study samples (see Table SI).(18, 23) Engel et al.. have published six of the 12 studies about pain since 1999.(7-9, 22, 23, 31) The three most common themes related to pain in the research literature are the prevalence of pain in adults with CP,(7-9, 17-19, 22, 23, 26, 30-32) the effect of pain on functional activities,(7, 9, 23, 31) and coping or intervention strategies for pain.(7-9, 22, 31) These themes mark a shift away from an impairment-based focus on pain to examining pain from the perspective of Activity and Participation, and contextual (Personal or Environmental) factors."
In a literature review of 12 studies on pain in adults with cerebral palsy, the three most common themes are 1) prevalence of pain, 2) the effect of pain on functional activities, and 3) coping or intervention strategies for pain.

Aisen, M. L., Kerkovich, D., Mast, J., Mulroy, S., Wren, T. A., Kay, R. M., & Rethlefsen, S. A. (2011). Cerebral palsy: Clinical care and neurological rehabilitation. The Lancet Neurology, 10(9), 844–852. doi:10.1016/S1474-4422(11)70176-4.
"The focus of rehabilitation treatment has recently shifted to neurological rehabilitation in response to increasing evidence for neuroplasticity. This approach aims to improve development and function by capitalising on the innate capacity of the brain to change and adapt throughout the patient's life."

Othman, M., Bhuiyan, N., & Kong, L. (2011). Developing a dynamic wheelchair using the design structure matrix method. Concurrent Engineering, 19(3), 235-243.
https://journals.sagepub.com/doi/abs/10.1177/1063293X11420176.
The goal of this article is to develop an instrumented, dynamic seating system for people with extensor thrust using the Design Structure Matrix (DSM) tool.

Cramer, S. C., Sur, M., Dobkin, B. H., O'Brien, C., Sanger, T. D., Trojanowski, J. Q., Rumsey, J. M., Hicks, R., Cameron, J., Chen, D., Chen, W. G., Cohen, L. G., deCharms, C., Duffy, C. J., Eden, G. F., Fetz, E. E., Filart, R., Freund, M., Grant, S. J., Haber, S., Kalivas, P. W., Kolb, B., Kramer, A. F., Lynch, M., Mayberg, H. S., McQuillen, P. S., Nitkin, R., Pascual-Leone, A., Reuter-Lorenz, P., Schiff, N., Sharma, A., Shekim, L., Stryker, M., Sullivan, E. V., … Vinogradov, S. (2011). Harnessing neuroplasticity for clinical applications. Brain: a journal of neurology, 134(Pt 6), 1591-609.
https://doi.org/10.1093/brain/awr039.
Common themes in plasticity that emerge across diverse CNS conditions include experience dependence, time sensitivity, motivation, and attention.

Pfeiffer, B. A., Koenig, K., Kinnealey, M., Sheppard, M., & Henderson, L. (2011). Effectiveness of sensory integration interventions in children with autism spectrum disorders: A pilot study. American Journal of Occupational Therapy, 65(1), 76-85.
https://ajot.aota.org/Article.aspx?articleid=1853012.
Vestibular input (movement) can reduce maladaptive behaviors.

Avellis, M., Cazzaniga, A., Cimolin, V., Galli, M., and Turconi, A.C. (2010). Dynamic seating vs. rigid seating: A quantitative comparison using 3d movement analysis in people with cerebral palsy. Posture and Mobility, 26(1):15–16.
(article available to members, https://www.pmguk.co.uk/journal/pmg-journal-1997-2014).
Quantitative movement analysis was used to compare movement during an extensor thrust with a dynamic back and with a rigid back. Results: decreased extensor thrust, increased range of motion in anterior-posterior direction, decreased vertical trunk movement during extension and decreased upper extremity movement (reduced large UE movement).

University of Denver. "Most concussions deliver 95 g's, neuropsychologist says." ScienceDaily. ScienceDaily, 25 June 2010.
www.sciencedaily.com/releases/2010/06/100624092526.htm.
Most concussions deliver 95 g's upon impact. The average football player receives 103 g's when hit during a game.

Cimolin, V., Piccinini, L., Avellis, M., Cazzaniga, A., Turconi, A. C., Crivellini, M., & Galli, M. (2009). 3D-Quantitative evaluation of a rigid seating system and dynamic seating system using 3D movement analysis in individuals with dystonic tetraparesis. Disability and Rehabilitation: Assistive Technology, 4(6), 422-428.
https://doi.org/10.3109/17483100903254553.
Full access version: http://www.r82.co.uk/media/417996/fumagalli_research_dynamic_v_rigid.pdf.
Study:
This study was done by Fumagalli in Italy. Quantitative movement analysis using 3D kinematics and pressure distribution was used to compare movement during an extensor thrust with a dynamic back and with a rigid back in ten people with cerebral palsy and dystonia. An R82 x:panda seating system was used.
Results:
Participants experienced decreased extensor thrust forces, increased range of motion in the anterior-posterior direction (the client could move their trunk forward and back), decreased vertical trunk movement during extension (shear) and decreased upper extremity movement (reduced large UE movement and increased smoothness of movement). The authors concluded that this could lead to increased occupant comfort (decreased pain) and quality of postural stability.

Hahn, M. E., Simkins, S. L., Gardner, J. K., & Kaushik, G. (2009). A dynamic seating system for children with cerebral palsy. Journal of Musculoskeletal Research, 12(01), 21-30.
https://www.worldscientific.com/doi/abs/10.1142/S0218957709002158.
Study:
The goal of this study was to determine the effects of a dynamic seating system (movement at hips and knees) as a therapeutic intervention in children with cerebral palsy. The study included twelve children: half received static seating and half received dynamic seating. Each child was evaluated in the areas of range of motion, muscle tone (Modified Ashworth Scale), motor function (Gross Motor Function Measure), and level of disability (Pediatric Evaluation of Disability Inventory) at initiation, 3 months and 6 months. A Kids Rock wheelchair was used.
Results:
Both groups improved in motor function (particularly in Sitting and Crawl/Kneel) and level of disability (self-care, mobility, social function). The authors concluded that a larger, more homogeneous group would likely show significant differences in muscle spasticity, gross motor function and disability. Trends showed a decrease in spasticity, an increase in range of motion and improvement on the GMFCS (Gross Motor Function Classification System) for crawling and walking.
Repetitive, high impact extensor thrusting can critically damage wheelchair seating systems, including failure of the back canes and frame, footrest hangers, and headrest mounts.

Van Geffen, P. (2009). Dynamic Sitting. Thesis. Institute for Biomedical Technology, Enschede. Amsterdam, The Netherlands.
https://www.xsens.com/wp-content/uploads/2014/01/Dynamic_Sitting_PhD_Thesis_vanGeffenP.pdf.
Development of a simulator that allows independent adjustment of trunk, pelvis, and thighs to improve posture.

Wittenberg, G. F. (2009). Neural plasticity and treatment across the lifespan for motor deficits in cerebral palsy. Developmental Medicine & Child Neurology,51, 130-133.
doi:10.1111/j.1469-8749.2009.03425.x.
Experience directed activity (self-directed movement) enhances and activates changes in brain structure and function. Children with cerebral palsy should have the potential to respond to experience directed activity (self-directed movement) in a similar way to adults, with the additional potential of regulation of neuronal development in response to injury (neural plasticity).

Haak, P., Lenski, M., Hidecker, M. J. C., Li, M., & Paneth, N. (2009). Cerebral palsy and aging. Developmental Medicine and Child Neurology, 51(Suppl 4), 16–23.
doi:10.1111/j.1469-8749.2009.03428.x.
A summary of epidemiology of CP throughout the lifespan, including functioning, ability, and quality of life of adults with CP.

Opheim, A., Jahnsen, R., Olsson, E., & Stanghelle, J. K. (2009). Walking function, pain, and fatigue in adults with cerebral palsy: A 7-year follow-up study. Developmental Medicine & Child Neurology, 51(5), 381–388.
doi: 10.1111/j.1469-8749.2008.03250.x.
Prevalence of pain in adults with CP

Pfeiffer, B., Henry, A., Miller, S., & Witherell, S. (2008). Effectiveness of Disc 'O'Sit cushions on attention to task in second-grade students with attention difficulties. American Journal of Occupational Therapy, 62(3), 274-281.
doi:10.5014/ajot.62.3.274.
Dynamic cushion demonstrated increased attention and alertness in response to movement.

Mcnamara, L., & Casey, J. (2007). Seat inclinations affect the function of children with cerebral palsy: a review of the effect of different seat inclines. Disability and Rehabilitation: Assistive Technology, 2(6), 309-318.
https://www.tandfonline.com/doi/abs/10.1080/17483100701661314.
Relationship of seat inclination and postural control.

Crane, B. A., Holm, M. B., Hobson, D., Cooper, R. A., & Reed, M. P. (2007). A dynamic seating intervention for wheelchair seating discomfort. American Journal of Physical Medicine & Rehabilitation, 86(12), 988-993.
https://journals.lww.com/ajpmr/Abstract/2007/12000/A_Dynamic_Seating_Intervention_for_Wheelchair.5.aspx.
Study:
The objective of this study was to examine the effectiveness of an experimental dynamic wheelchair seating system designed to relieve discomfort for long-duration wheelchair users. The study used the Tool for Assessing Wheelchair discomfort (TAWC). Two wheelchair users each tested an initial design and feedback guided the development of a second design.
Results:
The study found that dynamic seating reduced spasticity intensity and contact pressures, improved postural stability, increased comfort (decreased pain), improved function, prevented damage to the seating system, and increased vocal and/or breathing ability.

de Graaf-Peters, V. B., Blauw-Hospers, C. H., Dirks, T., Bakker, H., Bos, A. F., & Hadders-Algra, M. (2007). Development of postural control in typically developing children and children with cerebral palsy: possibilities for intervention? Neuroscience & Biobehavioral Reviews, 31(8), 1191-1200.
https://www.sciencedirect.com/science/article/pii/S0149763407000486.
Children learn to move by moving.

Sprigle, S. (2007). State of the science on wheeled mobility and seating measuring the health, activity and participation of wheelchair users. Disability and Rehabilitation: Assistive Technology, 2(3), 133-135.
https://doi.org/10.1080/17483100701396507.
Includes description of design project for a dynamic seating system for persons with extensor tone.

P. Incoronato: Dynamic seating for children and adults with multiple disabilities. Orthopedic technology. 2/2007, 92-97. https://www.tib.eu/de/suchen/id/tema%3ATEMA20070300132/Dynamische-Sitzversorgung-f%C3%BCr-Kinder-und-Erwachsene/.
Study:
This Retrospective study of the Aktivline dynamic seat occurred in Germany.
Results:
The study found that children and adolescents could sit longer, felt less pain, and demonstrated improved posture, joint mobility, and digestion.

A goal of dynamic seating is to reduce repair costs and costs of change.

Kitchen, J. (2006). Design of Wheelchair Seating Systems for Users with High-Tone Extensor Thrust. Thesis. 08/2006. Georgia Institute of Technology.
http://www.mobilityrerc.gatech.edu/publications/kitchen_james_p_200608_mast.pdf.
Design of “a dynamic seating system that moves with respect to the wheelchair frame, allowing the seat to move with the user during an extensor thrust.” “Dynamic configurations are very effective in reducing interaction forces at the seat back and improving comfort by reducing the peak pressures.” The dynamic seating system resulted in better contact between the cushion surface and the user. Dynamic Seating resulted in a 25% reduction of combined force over a static configuration. This would lead to less equipment breakage.

VP Patrangenaru: Development of a dynamic seating system for high-tone extensor thrust. Thesis. 05/2006. Georgia Institute of Technology.
https://smartech.gatech.edu/handle/1853/10438.
An analytical dynamic model of a human subject undergoing an extensor thrust on a rigid chair was created. A Dynamic-Hingeback Seating System was also developed. Desired motion of the system occupant during extensor thrust was verified.

Hong, S. W., Patrangenaru, V., Singhose, W., & Sprigle, S. (2006). A Method for Identifying Human-Generated Forces during an Extensor Thrust. International Journal of Precision Engineering and Manufacturing, 7(3), 67.
http://www.r82.co.uk/media/418002/hong_etal_methodidentifyingforces_clinbiomechanics2006_smarttechversion.pdf.
Development of a system to determine human-generated motions and forces during unconstrained extensor thrusts. Effectiveness and reliability established.

Hong, S. W., Patrangenaru, V., Singhose, W., & Sprigle, S. (2006). Identification of human-generated forces on wheelchairs during total-body extensor thrusts. Clinical Biomechanics, 21(8), 790-798.
https://www.sciencedirect.com/science/article/pii/S0268003306000751.
Development of a system to determine human-generated motions and forces during unconstrained extensor thrusts. Effectiveness and reliability established.
Similar to article above.

P. Incoronato (2006). Dynamic Seating: Characteristics, Indication and Efficacy. Orthopedic Technique 4/2006, 282-285.
https://www.tib.eu/en/search/id/tema:TEMA20060405082/Dynamische-Sitzversorgung-Eigenschaften-Indikation/.
Study:
This Retrospective study of the Aktivline dynamic seat also occurred in Germany.
Results:
This study showed reduction of pain and improvement of movement control of the upper extremities, trunk, and head.

Nithianantharajah, J., & Hannan, A. J. (2006). Enriched environments, experience-dependent plasticity and disorders of the nervous system. Nature Reviews Neuroscience,7(9), 697-709. doi:10.1038/nrn1970.
A review of findings on the environmental modulators of pathogenesis and gene-environment interactions in CNS disorders. Enriched environments can delay the onset and progression of motor symptoms in Huntington’s Disease (mouse model), can enhance learning and memory in people with Alzheimer’s disease, and have a positive impact on experience dependent plasticity in people with Parkinson’s disease, ALS, fragile X, Down syndrome and various forms of brain injury.
Enriched environments prolong critical periods of neuroplasticity (experience dependent plasticity).

Crane, B. A., Holm, M. B., Hobson, D., Cooper, R. A., Reed, M. P. & Stadelmeier, S. (2005).
Test-retest reliability, internal item consistency, and concurrent validity of the wheelchair

seating discomfort assessment tool. Assistive Technology, 17, 98-107.
doi:10.1080/10400435.2005.10132100. Study:
Purpose was to establish the test-retest reliability, internal item consistency, and concurrent validity of a newly developed Wheelchair Seating Discomfort Assessment Tool (WcS-DAT).
Results:
The tool was shown to be reliable and stable for quantifying wheelchair seating discomfort.

Rossini, P. M., & Dal Forno, G. (2004). Integrated technology for evaluation of brain function and neural plasticity. Physical Medicine and Rehabilitation Clinics, 15(1), 263-306.
https://doi.org/10.1016/S1047-9651(03)00124-4.
New understanding of adult plasticity of CNS and contributing factors.

Ferrari A. (2003). "In terms of posture and postural control (In tema di postura e di controllo posturale)", Giornale Italiano di Medicina Riabilitativa, 17 (1); 61-74.
(link unavailable)
Study:
This study was conducted in Italy.
Results:
Researchers observed that the use of a thoroughly designed dynamic seating system decreases intensity and duration of extension at the trunk and head, decreases hyperextension of the neck during spasms, decreases extension of the lower limbs, maintains body alignment with the components of the posture system during and after spasms, conserves energy consumption, and improves swallowing and, as a result, reduces drooling.

Geyer, M. J., Brienza, D. M., Bertocci, G. E., Crane, B., Hobson, D., Karg, P., ... & Trefler, E. (2003). Wheelchair seating: a state of the science report. Assistive Technology, 15(2), 120-128.
https://doi.org/10.1080/10400435.2003.10131896.
Seating discomfort was identified as a core area of concern.

McBurney, H., Taylor, N. F., Dodd, K. J., & Graham, H. K. (2003). A qualitative analysis of the benefits of strength training for young people with cerebral palsy. Developmental medicine and child neurology, 45(10), 658-663.
https://www.cambridge.org/core/journals/developmental-medicine-and-child-neurology/article/abs/qualitative-analysis-of-the-benefits-of-strength-training-for-young-people-with-cerebral-palsy/5AAF0821D5FF045234A5F247816ADD34.
Movement against resistance has been demonstrated to increase strength in people with increased muscle tone.

P. Incoronato: Use of dynamic seating shells in Dynamic Seating for children and adults with infantile cerebral palsy and after brain injury. Physiotherapy journal for physiotherapists. 5/2002, 764-769.
No longer available.

Briellmann, R.S., Abbott, D. F., Caflisch, U., Archer, J.S., & Jackson, G. D. (2002). Brain reorganization in cerebral palsy: a high-field functional MRI study. Neuropediatrics. 33(3):162-5.
DOI: 10.1055/s-2002-33680.
MRI study of a 15 year old with subcortical lesion. Movement was associated with the unusual pattern of bilateral cortical activation. Early brain damage may induce alternative organization of cortical brain functions.

Hobson, D. A., & Crane, B. (2001, February). State of the science white paper on: Wheelchair seating comfort. In Proceedings of the Conference on Seating Issues for Persons with Disabilities (pp. 29-33).
http://rercwm.pitt.edu/RERCWM_PDF/SoSReport.pdf#page=35.
Included use of dynamic seating for discomfort relief.

Fowler, E. G., Ho, T. W., Nwigwe, A. I., & Dorey, F. J. (2001). The effect of quadriceps femoris muscle strengthening exercises on spasticity in children with cerebral palsy. Physical Therapy, 81(6), 1215-1223.
https://doi.org/10.1093/ptj/81.6.1215.

Resistance training increases muscle strength without an increase in spasticity.

Taub, E., Crago, J.E., & Uswatte, G. (1998). Constraint-induced movement therapy: A new approach to treatment in physical rehabilitation. Rehabilitation Psychology, 43, 152-170.
https://psycnet.apa.org/doi/10.1037/0090-5550.43.2.152.
Constraint-induced movement therapy encourages movement of an affected extremity, improving motor control through neuroplasticity.

Watson, N. M., Wells, T. J., & Cox, C. (1998). Rocking chair therapy for dementia patients: Its effect on psychosocial well-being and balance. American Journal of Alzheimer's Disease and Other Dementias, 13(6), 296-308.
https://doi.org/10.1177%2F153331759801300605.
Movement reduced depression, anxiety, and pain. Significant improvements in balance were noted.

Engsberg J.R., Olree K.S., Ross S.A., Park T.S. (1996). Quantitative clinical measure of spasticity in children with cerebral palsy. Archives of Physical Medicine and Rehabilitation 77, 594-599.
https://www.archives-pmr.org/article/S0003-9993(96)90301-9/pdf.
Development of an objective measure to quantify the degree of spasticity.

Hutchinson, E. B., Riley, P. O., & Krebs, D. E. (1994). A dynamic analysis of the joint forces and torques during rising from a chair. Rehabilitation Engineering, IEEE Transactions on, 2(2), 49-56.
https://ieeexplore.ieee.org/document/313146/.
A method of calculating the net forces and torques on human joints using inverse dynamics and an 11 segment model of the human body.

Non-Peer Reviewed Publications

Lange, M. (2022). Using Dynamic Seating to Reduce Client Injury and Equipment Damage. NRRTS Directions, Vol. 4. (pgs. 40-43). https://issuu.com/nrrts/docs/directions_2022v4_issuu/s/16445541.

Haar, B. (2022). Let’s get it clear: Dynamic Seating – What does it involve? AT Today.
https://attoday.co.uk/lets-get-it-clear-dynamic-seating-what-does-it-involve/.

Dias, M. N. (2021). Development of a Dynamic Wheelchair Lateral Support (Doctoral dissertation, Rutgers The State University of New Jersey, School of Graduate Studies).
https://www.proquest.com/openview/2aa3e99b312ac2c7914b7156702ad8ce/1?pq-origsite=gscholar&cbl=18750&diss=y.

Mallory, S. (2020). Dynamic Seating Systems for Children with Severe Movement Limitations Possibilities and Documented Effects.
No longer available.

Mallory, S. (2019). Understanding Dynamic Seating. Blog. Convaid, R82.
No longer available.
Children with involuntary extensor thrust exert very large forces against the back, headrest, and footrest which can lead to skin breakdown and difficulty maintaining the pelvic in neutral due to destabilization of the hip joint.

Lange, M. (2018). Let’s Get Moving! Providing Movement within a Wheelchair Seating System. Exceptional Parent.
https://www.eparent.com/eparent-connect/lets-get-moving-providing-movement-within-a-wheelchair-seating-system/.

A case study of a young man with cerebral palsy and clinical benefits of dynamic seating.

Eason, S. (2018). Movement and Neuroplasticity. Directions, (2), 28-30.
https://mydigitalpublication.com/publication/?m=&l=1&i=488749&p=30&ver=html5.
Movement within a wheelchair seating system can enrich environments, leading to positive brain changes through neuroplasticity.

Choosing the Right Dynamic Seating. (2018). Astris PME, Australia.
https://www.astris-pme.com.au/news/choosing-the-right-dynamic-seating.
An overview of dynamic seating clinical indicators.

Dauphin. (2018). Dynamic Seating.
https://www.dauphin-france.com/partner_portal/downloads/dauphin/ergonomie/Ergonomie-Broschuere_EN.pdf.
The impact of static seating. Ergonomic furniture.

Ingraham, P. (2018). Microbreaking. PainScience.com
https://www.painscience.com/articles/microbreaking.php.
Dynamic ergonomics concept. Microbreaks are regular, small, biologically meaningful breaks from a static position. Many small breaks are more effectively than fewer longer breaks.

Ingraham, P. (2018). The Trouble with Chairs. PainScience.com
https://www.painscience.com/articles/chair-trouble.php.
Research has found that microbreaks and mobilizing are important in combating consequences of prolonged sitting.

Lange, M. (2017). Dynamic Seating: The Results are In! Mobility Management.
https://mobilitymgmt.com/Articles/2017/02/01/Dynamic-Seating.aspx.
The results of a survey on use of dynamic seating in the United States.

Innovations in Supported Sitting. (2017). Herman Miller Solution Essay.
https://www.hermanmiller.com/research/categories/white-papers/innovations-in-supported-sitting/.
Movement is human nature and moving between supported positions helps the muscular and skeletal systems. It also helps mental stamina and the ability to concentrate (Dr. Brock Walker, expert on musculoskeletal disorders).

Thomas, L. E. (2017). Modelling the stability and maneuverability of a manual wheelchair with adjustable seating (Doctoral dissertation, Applied Sciences: School of Mechatronic Systems Engineering).
http://summit.sfu.ca/item/17546.
Featuring the Elevation dynamic wheelchair.

Eason, S. (2015). Enhancing Development with Dynamic Wheelchair Components. Directions, (4), 50-52.
https://www.bluetoad.com/publication/?m=3586&i=270359&p=52&pre=1.
An overview of dynamic seating and a case study.

Freney, D. and Schwartz, K. (2015). Dynamic Seating. Directions, (4), 45 – 48.
https://www.bluetoad.com/publication/?m=3586&i=270359&p=46&pre=1.
An overview of dynamic seating and a case study.

Breithecker, D. (2015). Bodies in motion. Brains in motion. An active solution to learning and being. VS America, Inc.
https://network.aia.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=a0cff0a7-0b52-41ea-a4b0-8b54e7401179lumb.

Inactive sitting places greater stress on the tissues and systems of the body, the person becomes uncomfortable, tired, and less productive. Dynamic seat (office chair) has been shown to increase attention and concentration. Moving the legs improves blood flow to the heart and brain.

Rethinking Corporate Wellness: why Active Design and Tech may be the Best Place to Start. (2015). White Paper, Humanscale.
https://www.humanscale.com/userfiles/file/RethinkingCorporateWellness_Whitepaper_Oct-2015.pdf.
Paper explores the effects arising from corporate wellness programs. Companies who want to improve employee well-being are using active design. Increases in small movements improve energy and function and decrease tension and depression.

Puleio, J. & Zhao, J. (2015). Return on Investment for Ergonomics Interventions. Humanscale.
https://www.humanscale.com/userfiles/file/return-on-investement_03272015.pdf.
Ergonomic interventions (including active seating) yield a positive return on investment in terms of decreased injury and productivity.

Samaneein, K. (2014). Biomechanical comparison of a rigid and dynamic seating system for children with special needs (Doctoral dissertation, University of Strathclyde).
http://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.605962.
This project shows that the development of a fully mobile data acquisition system is achievable and practical. Results obtained from twelve children during their communit- based activity of daily living showed no significant differences in the mean and peak interface forces on the backrest between the rigid and dynamic systems. However, when using the dynamic backrest system, a significant decrease in force and bending moments were observed on the right footrest, the dominant side of most participants.

Berkowitz, B. & Clark, P. (2014). The Health Hazards of Sitting. The Washington Post.
http://apps.washingtonpost.com/g/page/national/the-health-hazards-of-sitting/750/.
Prolonged static movement increases risk of heart disease; overproductive pancreas; colon, breast and endometrial cancer; muscle degeneration and tight hip flexors; poor circulation in legs; osteoporosis; decreased brain function; strained neck, sore shoulders and back; loss of spine flexibility and disk damage.

Deyo-Obler, L. (2013). Dynamic Seating and Pelvic Positioning Blog
http://www.rifton.com/adaptive-mobility-blog/blog-posts/2013/may/dynamic-seating-for-children-disabilities.
A general overview of the need for dynamic seating and a stable pelvis.

Supporting the Spine When Seated. (2013). Solution Essay. Herman Miller.
https://www.hermanmiller.com/research/categories/white-papers/supporting-the-spine-when-seated/.
Civilian American and European Surface Anthropometry Resource (CAESAR) survey results, a large scale, three-dimensional anthropometric survey of civilians in the several countries. The pelvis dictates the curve of the spine in all seated postures. When the pelvis rotates rearward, pressure increases on the intervertebral discs and muscle activity increases. The can lead to muscle fatigue and discomfort. Seated people move their torso an average of 53 times an hour.

The Art and Science of Pressure Distribution. (2013). Solution Essay. Herman Miller.
https://www.hermanmiller.com/research/categories/white-papers/the-art-and-science-of-pressure-distribution/.
As the sitter changes posture from upright to recline, pressure-distribution changes.

Freney, D. (2012). Dynamic Seating is Important. Rifton blog.
https://www.rifton.com/adaptive-mobility-blog/blog-posts/2012/may/dynamic-seating-position.
Definition and clinical indicators.

Rexroth Bosch Group. (2012). Dynamic Seating – Ergonomic and Functional
https://www.airlinehyd.com/literature_catalog/bosch%20rexroth/seating-ergonomic-r999000144_2012-06.pdf.

Ergonomic furniture with adjustments and movement to improve posture. Poor posture leads to muscle, spine, and joint pain.

Watanabe, L. (2011). Dynamic Seating: a moving alternative. Mobility Management.
https://mobilitymgmt.com/articles/2011/11/01/dynamic-seating.aspx.
Introduction to Dynamic Seating.

Watanabe, L. (2011). Keeping Kids in Motion: defining dynamic seating & determining the benefits. Mobility Management.
https://mobilitymgmt.com/Articles/2011/02/01/Keeping-Kids-in-Motion.aspx.
Dynamic seating clinical indicators and product considerations.

Feodoroff, B. & Frobose, I. (2011). Three-dimensional dynamic seating for more efficient office work. Center for Health – the holistic health portal. The German Sport University, Cologne, Germany.
https://www.wilkhahn.com/fileadmin/user_upload/Wilkhahn-Study-ZfG-Trimension-eng.pdf.
A study on the impact of the three-dimensional office chair system ON® on cognitive skills and the subjective feeling of well-being. Half of 80 participants trialed the three-dimensional office chair for 12 weeks. Test results showed significant improvements in concentration. Participants indicated increased movement, more varied movement, physical feeling of well-being, better postural support, and increased comfort.

Sturgeon, J. (2010). Dynamic Seating Poised to Move Mobility Market Forward. Mobility Management.
https://mobilitymgmt.com/articles/2010/05/05/dynamic-seating-tech.aspx?sc_lang=en.
Dynamic seating coding and product considerations.

Zollars, J. (2010). Special Seating: An Illustrated Guide. Prickly Pear Publications.
https://seatingzollars.com/.
Addresses dynamic seating.

Springer, T. (2010). The Future of Ergonomic Office Seating. White Paper. Knoll Workplace Research.
https://www.knoll.com/document/1352940440338/wp_future_ergonomic_seating.pdf.
A chair should promote movement, move with the user, and make it easy to move. It should facilitate, support and enable effective performance. A chair needs to provide cognitive ergonomics to facilitate focus, attention and memory.

Lange, M. (2009). Dynamic Seating: A Case Study. Directions, (3), 44 – 46.
http://www.nrrts.org/pdfs/CaseStudies/Directions_vol5_2009_44_46.pdf.
A case study of a client using dynamic seating and the clinical benefits.

Watanabe, L. (2008). Editors at Large: A.R.T. Group's Kids Rock Active Chair. Mobility Management. https://hme-business.com/articles/2008/01/07/editors-at-large-art-groups-kids-rock-active-chair.aspx.
A focus on the Kids Rock dynamic wheelchair.

Doidge, N. (2007). The Brain That Changes Itself: Stories of Personal Triumph from the Frontiers of Brain Science. Penguin Group, New York City.
https://books.google.com/books?hl=en&lr=&id=Qw7qj5nXSPUC&oi=fnd&pg=PP1&dq=The+Brain+That+Changes+Itself:+Stories+of+Personal+Triumph+from+the+Frontiers+of+Brain+Science&ots=NcPlkYqfKY&sig=hKLXSdwst5BXQEvWN_7rV_a3_Ss#v=onepage&q=The%20Brain%20That%20Changes%20Itself%3A%20Stories%20of%20Personal%20Triumph%20from%20the%20Frontiers%20of%20Brain%20Science&f=false.
Neuroplasticity.

Lueder, R. (2004). Ergonomics of seated movement: a review of the scientific literature. Considerations relevant to the Sum chair. Written for Allsteel. Humanics ErgoSystems, Inc.
http://www.allsteeloffice.com/SynergyDocuments/SUMErgoReviewRaniLueder.pdf.

Not moving is harmful, contributes to backpain and injury, contributes to leg edema, and causes discomfort/pain. Constrained sitting is uncomfortable and static postures contribute to arthritis, inflamed tendons and tendon sheaths, chronic joint degeneration, muscle pain, impaired circulation and tissue damage. Also, keeping the center of rotation of a moving back close to the client's center of rotation at the pelvis reduces shear. The only effective way to maintain a seated posture for extended durations is to dynamically shift between a range of stable positions.

Lange, M. (2000). Focus on…. Dynamic seating. Occupational Therapy Practice, (5), 21-22.
Link not available.
General article on dynamic seating, definition, clinical indicators.

Riley, K., Levy, B. (1993). Getting it right., Team Rehab Report (4) 8.
Link not available.
A seating system that accommodated to changes in position for a child with constant fluctuations with extension, flexion, and rotation. A Roho cushion was used to accommodate postural needs and provide a degree of movement.

Health Impact Study: Leap Chair (undated). Steelcase.
https://www.steelcase.com/research/articles/topics/wellbeing/leap-productivity-health-impact-study/.
In a year long study, people using the Leap chair (ergonomic dynamic office chair) achieved up to a 17.8% increase in productivity. Over 450 participants at two companies participated. Participants reported significantly lower pain and discomfort and overall musculoskeletal symptoms were lower.

Movement Improves Employee Wellbeing (undated). Steelcase.
https://www.steelcase.com/research/articles/topics/ergonomics/movement-in-the-workplace/.
Sitting for long periods with little movement can impact health and function.

Posture Support in a Changing Workplace (undated). Steelcase.
https://www.steelcase.com/research/articles/topics/wellbeing/posture-support-changing-workplace/.
Reclining postures reduce the load measured in the intervertebral discs. Posture variability is detrimental to the body. Maintaining one position causes the muscles and ligaments supporting the back to become fatigued. Changing position pushes used fluids out of the vertebral discs and draws in fresh nutrients.

Presentations and Proceedings

Buck, S. (2022). Advancements in Technology: Considerations for Pain Reduction Through Dynamic Seating Interventions. European Seating Symposium. Dublin, Ireland.

Bjornson, A., Norman, R. (2022). Managing Forces in Active Bodies. Dynamic Seating from Theory to Practice. Oceana Seating Symposium, virtual.

Ball, M., Lange, M., Shea, M. (2022). Dynamic Seating – Diverse Applications: a series of case studies. International Seating Symposium. Virtual.

Lange, M. (2021). Dynamic Seating for Clients with Increased Muscle Tone. Linds Rehabilitation Equipment. VIC, Australia. (virtual).

Lange M. (2021). Dynamic Seating. New Mexico Mobility and Positioning Conference. (virtual).

Lange, M. (2021). Muscle Tone: Definitions, Etiology, Pathophysiology and Related Diagnoses; Muscle Tone and Movement Disorders: Challenges with Wheelchair Seating; and Dynamic Seating Interventions for Tone and Movement. Webinar series. LC Seating training event, Ireland. (virtual).

Lange, M. (2021). Dynamic Seating. Apexpo, Wheelchair Seating & Mobility Assistive Technology Expo. Australia. (virtual).

Lange, M. (2021). Dynamic Seating: moving beyond static wheelchair seating. HomeCEU.

Lange, M. (2021). Dynamic Seating. Numotion webinar.

Mallory, S. (2020). Dynamic Seating Systems for Children with Severe Movement Limitations: possibilities and documented effects. ETAC Webinar.

Lange, M. (2020). Dynamic Seating: myth busters. Numotion webinar.

Kerst B, Crouch L, Fox J, et al. Effects of a head support on children with hypotonia in the cervical spine. Proc Annu Int Conf IEEE Eng Med Biol Soc EMBS. University of Tulsa, Department of Mechanical Engineering, Tulsa, OK; 2020. p. 4783–4786. Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85090998714&doi=10.1109%2FEMBC44109.2020.9175744&partnerID=40&md5=8b1f200bad7a05166ad45063971a5b5b. [Google Scholar]
Impact of Headpod.

Lange, M. (2020). Dynamic Seating. TIES Conference, Salem, OR.

Lange, M. & Crane, B. (2020). The RESNA Position on the Application of Dynamic Seating. International Seating Symposium. Vancouver, BC.

Lange, M. (2020). Dynamic Seating – who can benefit from this technology. NRRTS webinar.

Lange, M. (2019). Dynamic Seating: a series of case studies. Numotion webinar.

Eason, S., Lange, M., Presperin Pedersen, J., Sparacio, J. (2019). Dynamic Seating – exploring theory, research, and products. International Seating Symposium. Pittsburgh, PA

Lange, M. (2019). 3 Ways to Keep Your Client's Head Up! (including dynamic options). International Seating Symposium, Pittsburgh, PA

Lange, M. (2019). Dynamic Seating. AbleNet webinar.

Sparacio, J. (2018). The Benefits of Dynamic Seating for Individuals with Abnormal Tone Patterns. NRRTS webinar.

Lange, M. (2018). Dynamic Seating: protecting both client and equipment from harm. Numotion webinar.

Lange, M. (2018). Dynamic Seating: diffusing and moving! Numotion webinar.

Lange, M. (2018). Positioning the Head (including dynamic options). Numotion webinar.

Adlam, T. and Gimeno, H. (2018). A Feasibility Trial of a Whole Body Dynamic Seating System for Preschool Children with Dystonia: Aims, Methods and Measures. International Seating Symposium, Vancouver, BC. Proceedings, pgs. 111-114.
http://www.seatingsymposium.com/images/pdf/ISS2018_Syllabus_eVersion.pdf.

This session presented a current feasibility trial to guide and inform the design of a full scale trial to assess acceptability and efficacy of whole-body dynamic seating on activity, participation, and quality of life in preschool children with dystonic cerebral palsy, using mixed qualitative and quantitative methods.

Adlam, T., Gimeno, H., Field, D., Livingstone, R., Long, D, Maguire, H. (2018). Update on Systematic and Scoping Reviews on Dynamic Seating for People with Dystonia. Posture and Mobility Group conference.

Lange, M., Presperin Pedersen, J. (2018). Dynamic Seating – enhancing participation through movement., International Seating Symposium, Vancouver, BC.

Lange, M. (2018). Is Your Client Stuck? Dynamic Seating Gets Things Moving! Travis Medical. Georgetown, TX.

Lange, M. (2018). Is Your Client Stuck? Dynamic Seating Gets Things Moving! National Seating and Mobility, Oklahoma City, OK.

Lange, M. (2017). Dynamic Seating. OccupationalTherapy.com webinar.

Lange, M. (2017). Dynamic Seating, NuFair, Portland, OR.

Lange, M. (2017). Dynamic Seating, NuFair, Seattle, WA.

Ball, M. (2017). Dynamic vs. Non-Dynamic Seating including vests and belts. Convaid webinar.

Eason, S. (2017). Dynamic Seating to Provide Vestibular Input. NRRTS webinar.

Sparacio, J. (2017). Dynamic Components for Dynamic People, Canadian Seating and Mobility Conference, Toronto, Canada. Proceedings, pgs 46-48. (presented by Stephanie Tanguary, OT/L, ATP).
https://www.seatingdynamics.com/wp-content/uploads/2018/01/2017-Canadian-Seating-Proceedings-Sparacio-paper.pdf

Lange, M., Presperin Pedersen, J., Sparacio, J., Eason, S., Sutherland, S. (2017). Dynamic Seating – Providing Movement and Why. International Seating Symposium, Nashville, TN.
Proceedings: https://www.seatingdynamics.com/wp-content/uploads/2017/02/ISS-2017-Proceedings-Paper-Dynamic-Seating.pdf

Lange, M. (2017). Positioning the Head (including Dynamic options). International Seating Symposium, Nashville, TN.
http://www.rstce.pitt.edu/RSTCE_Webinar/2017/RST_CE_0304_17.html

Lange, M. (2017). Dynamic Seating, NuFair, Salisbury, MD.

Lange, M. (2017). Is Your Client Stuck? Dynamic Seating gets things Moving! Webinar, Numotion.

Thomas, L., Borisoff, J., & Sparrey, C. J. (2017, July). Quantifying the effects of on-the-Fly changes of seating configuration on the stability of a manual wheelchair. In 2017 39th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC) (pp. 1897-1900). IEEE.
Featuring the Elevation dynamic wheelchair.

Thomas, L., Borisoff, J., & Sparrey, C. (2017). Defining the stability limits of a manual wheelchair with adjustable seat and backrest. In Rehabilitation Engineering and Assistive Technology Society of North America Conference. New Orleans, LA.
Featuring the Elevation dynamic wheelchair.

Adlam, T., Morris, C., McFadden, H., Dutton, A. (2016). Designing for Dystonia: Begin at the Beginning with Children, Parents and Therapists. International Seating Symposium, Vancouver.
Proceedings, pgs. 64-68.
http://www.seatingsymposium.com/images/pdf/2016Syllabus.pdf
At the time of this presentation, this group was designing a seating system for children ages two to five years with whole body dystonia. They were also determining the feasibility of evaluating the impact of the seat with functional outcome measures suitable for use with this group, as preparation for a subsequent trial with a group of six children. Item #2 on this list presents their progress.

Freney, D. and Schwartz, K. (2016). Dynamic Seating. Canadian Seating and Mobility Conference. Toronto. Proceedings pgs. 48-51.
http://www.csmc.ca/docs/archives/2016_archive/ws/WS26%20-%20DYNAMIC%20SEATING.pdf

Collin, T. (2016). Dynamic Seating – Creating Possibilities. European Seating Symposium.

Lange, M. (2016). Dynamic Seating. Webinar, AbleNet.

Lange, M. (2016). Dynamic Seating. Webinar. HomeCEUConnection.

Eason, S. (2016). Dynamic Seating. Webinar, NRRTS.

Lange, M. (2016). Dynamic Seating. NuFair, Philadelphia, PA.

Crane, B. (2015). Dynamic Seating: Principles and Practices for Clients with Neurological Diagnoses, Numotion conference, Salisbury, MD.

Crane, B. (2015). Effects of Dynamic Wheelchair Seating on Pressure, Motion, and Propulsion. International Seating Symposium, Nashville, TN. Proceedings, p. 159.
http://www.iss.pitt.edu/ISS_Pre/Iss_Pre_Doc/ISS_2015.pdf
This session presented research that was on-going and stated that long-term testing was underway. The study was testing whether the KiSS dynamic seating system impacted body motion or seat interface pressure.
Results:
Preliminary testing did not show a significant effect.

Presperin Pedersen, J. and Eason, S. (2015). Using Seating to Enhance Movement of the Body in the Wheelchair. International Seating Symposium, Nashville, TN. Proceedings pgs. 319-321.
Proceedings paper: http://www.iss.pitt.edu/ISS_Pre/Iss_Pre_Doc/ISS_2015.pdf
Recording: https://www.youtube.com/watch?v=LO4y_VeHn8k&feature=youtu.be.

Collin, T. (2015). Dynamic Seating – creating possibilities. Nordic Seating Symposium, Oslo.

Lange, M. (2015). Dynamic Seating webinar, Numotion.

Adlam T (Designability), Orpwood R (University of B), Wisbeach A (Great OSH), Alger H (Great OSH), Johnson E (Great OSH). (2014). Whole Body Dynamic Seating for Children with Extensor Spasms. In: Cooper D, Story M, editors. 30th International Seating Symposium. Vancouver: Interprofessional Continuing Education, University of British Columbia. pp. 182–185.
http://seatingsymposium.com/images/pdf/2014Syllabus.pdf
This session describes the development of a novel dynamic seating system. Initial prototypes were evaluated by two children. The final prototype was then used in further studies (see items #2 and #14 above).
Results:
The following outcomes were noted: increased vocalization, increased movement, one child was able to access a switch in the dynamic seat (and unable to in their static seating), reduced spasm intensity, increased symmetry in

posture, increased head control, and the onset of movement (of the dynamic seat) reduced the rate of increase of spasm. The client also expressed preference for the dynamic option.

Dalton (2014). An Evaluation of a Simulated Dynamic Foot Support. International Seating Symposium, Vancouver, BC. Proceedings, pgs. 64-67.
http://seatingsymposium.com/images/pdf/2014Syllabus.pdf
This session described an evaluation of the impact of a simulated dynamic foot support on an adult with Dystonic cerebral palsy who experiences whole body extensor spasms. This study was designed to optimize the mechanical design of the foot support to then use in a pilot study scheduled for February 2014. It is unknown if this study occurred.
Results:
Use of the simulated foot support increased head and arm control and the client reported that it was easier to drink and swallow. It should be noted that the simulated support was provided only by the clinician's hands.

Lange, M. (2014). Dynamic Seating webinar, RESNA.

Lange, M. (2014). Dynamic Seating webinar, NRRTS.

Samaneein, K., Greene, P., Lees, K., and Riches, P. (2013). Comparison of Imparted Forces between Rigid and Dynamic Seating Systems during Activities of Daily Living by Children with Cerebral Palsy. Congress of the International Society of Biomechanics, Brazil.
https://isbweb.org/images/conferences/isb-congresses/2013/oral/cb-cp-stroke-spasticity.03.pdf
A mobile strain gauge data acquisition system was developed to capture the forces and moments in wheelchair components in a rigid and dynamic seating system. The research team determined the magnitude of the contact force on the backrest, footrests and center of pressure (COP) on the seat during ADLs (Activities of Daily Living). Footrest forces and moments varied, but back support interface forces remained the same for each system (static and dynamic). Average force on the backrest was 60-70% BW (Body Weight) and 20% BW on each footrest. Peak forces (during extension) were 200% BW on backrest and 600% BW on footrests.
Results:
Clients are able to exert up to 200% of their body weight against the backrest and 600% of their body weight against the footrests during extension. Dynamic seating can be used to diffuse these forces.

Adlam, T., Orpwood, R., Wisbeach, A. (2013). Experiences and Research into Dynamic Seating for People with Severe Extensor Spasms. Annual Conference Posture and Mobility Group, University of the West of England.

Samaneein, K., Greene, P., Lees, K., & Riches, P. (2013). A comparison of force exerted on rigid and dynamic backrest system by children with cerebral palsy. Paper presented at European Seating Symposium incorporating Assistive Technology, Dublin, Ireland.

Lange, M. (2013). Dynamic Seating webinar, National Seating & Mobility.

Doherty, J. (2013). "Freedom" – An Overview of Functional & Therapeutic Benefits of Dynamic Seating, International Seating Symposium, Nashville, TN. Proceedings, p. 173 – 174.
http://www.iss.pitt.edu/ISS2013/ISS2013Program/RST_CE_0125_12web.pdf

Borisoff, J. F., Mattie, J., & Rafer, V. (2013, June). Concept proposal for a detachable exoskeleton-wheelchair to improve mobility and health. In 2013 IEEE 13th International Conference on Rehabilitation Robotics (ICORR) (pp. 1-6). IEEE.
Proposal for a system to combine a detachable exoskeleton and a wheelchair with dynamic seating functions.

G, K. et al. (2012). Assessment of forces imparted on seating systems by child with special needs during daily living activities. In Biomedical Engineering and Sciences (IECBES), 2012 IEEE EMBS Conference, pp 475-478.

Samaneein, K. et al. (2012). Assessment of Seating Forces Imparted Through Daily Activity by Children with Special Needs. International Seating Symposium, Vancouver, BC. Proceedings, pgs. 80-83. http://seatingsymposium.com/images/pdf/2012Syllabus.pdf.

Eason, S. (2011). Dynamic Seating: Why, Who, How, International Seating Symposium, Nashville, TN. Proceedings, page 275-276.
http://www.iss.pitt.edu/iss_pre/iss_pre_doc/iss_2011.pdf.

Paleg, G. (2011). Dynamic Seating webinar. Rifton.

Lange, M. (2011). Providing Dynamic Stability webinar, Bodypoint.

Borisoff, J. F., & McPhail, L. T. (2011). The development of an ultralight wheelchair with dynamic seating. RESNA Conference, Toronto, Proceedings, pp. 1-4.
https://www.resna.org/sites/default/files/legacy/conference/proceedings/2011/RESNA_ICTA/borisoff-69725.pdf.
Describes the Elevation wheelchair which is an ultralight rigid manual wheelchair that allows the client to adjust the seat height (posterior portion raises) and backrest recline angle. The chair weighs less than 25lbs. It is operated by 2 gas springs under the seat and a lever.
The authors define dynamic seating as "the user's ability to easily and quickly adjust their seating position independently."

K Samaneein and P Riches. (2011). Development of a fully mobile, strain gauged seating system for assessment of forces imparted on the Mygo seating system by children with special needs through daily activity. In Olwen Ellis, editor, Proceedings of the Posture and Mobility Group National Training Event, Birmingham, England.
Available on request from the author: philip.riches@strath.ac.uk / bioengineering1@hotmail.com.

Brinks and Paleg. (2010). Sensory Input Processing in Dynamic Seating, International Seating Symposium, Vancouver, BC. Proceedings, pgs. 48-51.
http://seatingsymposium.com/images/pdf/2010Syllabus.pdf
Addresses microstimulation in seating systems

Cimolin, V. (2009). Dynamic Seating vs. Rigid Seating: a comparison using 3D. International Seating Symposium. Proceedings, pg. 177. (no full online Proceedings)

Emiliani, P. L. (2009). Supporting Inclusion and Independence: Compliant Seating for Children with Cerebral Palsy and Whole Body Extensor Spasms. Assistive Technology from Adapted Equipment to Inclusive Environments: AAATE 2009, 25, 52.
A case study describing a seat designed with dynamic footrests and a dynamic back. The child showed reduced muscle tone and improved head and hand control.

Campbell, G. (2009, February 13). Michael Merzenich on Neuroplasticity. Brain Science Podcast, 54. Retrieved from http://www.brainsciencepodcast.com/storage/transcripts/bsp-year-3/54-brainscience-Merzenich.pdf.

Hahn and Simkins. (2008). Effects of Dynamic Wheelchair Seating in Children with Cerebral Palsy International Seating Symposium, Vancouver, BC. Proceedings, pgs. 153-157.
http://seatingsymposium.com/images/pdf/2008Syllabus.pdf.
Study reported a decrease in spasticity, an increase in range of motion and improvement on GMFCS, the positive effects of the dynamic posture system in subjects with children brain paralysis when in the seated position and during daily activities.

Hahn, M. (2007). Effects of Dynamic Wheelchair Seating on Spasticity and Functional Mobility in Children. International Seating Symposium, Orlando, FL. (not in Proceedings)

Cooper D., Antoniuk E. (2007). Dynamic Seating – A spectrum of applications. International Seating Symposium, Orlando, FL., Proceedings, pgs. 87-88.
http://www.iss.pitt.edu/ISS_Pre/ISS_Pre_Doc/ISS_2007.pdf

Cooper D., Antoniuk E., Taylor S.J. (2007). Dynamic Posture Control, European Seating Symposium, Dublin (Irl).

Taylor, S., Seikman, A., Cooper, D. (2006). Putting the "Dynamic" Back in Seating. International Seating Symposium, Vancouver, BC., Proceedings, pg. 215.
http://seatingsymposium.com/images/pdf/2006Syllabus.pdf.

Hong, Patrangenaru, Singhose, Sprigle. (2005). Motion Measurement and Force Determination during Unconstrained Extensor Thrust. RESNA Conference, Atlanta, GA.
https://www.resna.org/sites/default/files/legacy/conference/proceedings/2005/Research/SM/Hong.html.

Hong SW, Seomoon H, Patrangenaru V, Singhose W and Sprigle S, (2005). An efficient identification method for human-generated forces during extensor thrust. Biomedical Engineering Conference, Innsbruck, Austria.

Kangas, K. (2005). Sensory Systems and Seating for Function: The Need for Both Active Postural Control (Use of the Vestibular System) and Passive Postural Management (Use of the Tactile System). International Seating Symposium, Orlando, FL. Proceedings, pgs. 47-48.
http://www.iss.pitt.edu/ISS_Pre/ISS_Pre_Doc/ISS_2005.pdf.

Siekman A. (2005) Stable, not static: dynamic seating to improve movement and function. Proceedings of the International Conference on Posture and Wheeled Mobility, Exeter, England.

Siekman AR, Hurley SL, Yamada DA, Hayes AM, Noon JH, Axelson PW (2003). Functional benefits of a dynamic pelvic stabilization system. International Seating Symposium, Orlando, FL.

Kangas, K. (2004). Sensory Processing & Sensory Integration in Children's Seating and Mobility Systems. International Seating Symposium, Vancouver, BC. Proceedings, pg. 99.
http://seatingsymposium.com/images/pdf/2004Syllabus.pdf.

McLean, L. (2004). A Mobile Rocker Base to Provide Calming Sensory Input. International Seating Symposium, Vancouver, BC. Proceedings, pg. 295.
http://seatingsymposium.com/images/pdf/2004Syllabus.pdf.

Crane, B. A., Holm, A. M. B., & Hobson, A. D. (2003). Development of a wheelchair seating discomfort assessment tool (WCS-DAT). In Pre-Symposium Workshops Wednesday, February 26, 2003 (p. 43).

Dawley J, Julian R. (2003). Purpose, use and fabrication of a custom made dynamic backrest. International Seating Symposium, Orlando, FL. Proceedings, pp. 145–147.
http://www.iss.pitt.edu/ISS_Pre/ISS_Pre_Doc/ISS_2003.pdf.

Magnuson S, Dilabio M. (2003). Dynamic seating components: The best evidence and clinical experience. International Seating Symposium, Orlando, FL. Proceedings, pp. 109–111.
http://www.iss.pitt.edu/ISS_Pre/ISS_Pre_Doc/ISS_2003.pdf.

Meeker P, van der Heyden B. (2002). Dynamic seating and positioning with the young wheelchair user: An overview of functional aspects using case studies. International Seating Symposium, Vancouver, BC, Proceedings, p. 77.

Brown, D. (2002). Dynamic Wheelchair seating for individuals with fluctuating muscle tone, unpublished thesis: University of Pittsburgh: Pittsburgh.

Brubaker, C. E. & Brienza, D. M. Eds. (2001). Wheelchair Seating: A state of the science conference on seating issues for persons with disabilities. Rehabilitation Engineering Center on Wheeled Mobility and the School of Health and Rehabilitation Sciences at the University of Pittsburgh, Pittsburgh.

Brown, D. (2001). State of the science in dynamic seating components. Seventeenth International Seating Symposium, Orlando, FL.

Cooper D., Dilabio M., Broughton G., Brown D. (2001). Dynamic seating components for the reduction of spastic activity and enhancement of function", International Seating Symposium, Orlando, FL, Proceedings, pp. 51–57. http://www.iss.pitt.edu/ISS_Pre/ISS_Pre_Doc/ISS_2001.pdf.
Shows that a dynamic seating system may positively affect the reduction of spasticity and the increase of certain functional activities.

Trefler, E., & Schmeler, M. (2001, February). State of the science white paper on seating for postural control. In Proceedings of Wheelchair Seating: A State of the Science Conference on Seating Issues for Persons with Disabilities, Orlando, Florida (pp. 21-26).
Lack of dynamic seating options to respond to high tone, perhaps due to lack of evidence.

Brown D., Zeltwanger AP, Bertocci G. (2001). Quantification of forces associated with full body extensor thrust in children. International Seating Symposium, Orlando, FL., Proceedings, pgs. 165-167. http://www.iss.pitt.edu/ISS_Pre/ISS_Pre_Doc/ISS_2001.pdf.

Brown D., Zeltwanger A.P., Bertocci G., Burdett R, Fitzgerald S, and Trefler E. (2001). Quantification of forces associated with episodic full-body extensor spasticity in children. RESNA Conference, Reno, NV. Brown, D., Zelwanger, A., and Bertoci, G. (2001). Quantification of Forces associated with Episodic full body extensor spasticity in children. RESNA, p. 358-60.

Zeltwanger, Brown, and Bertocci. (2001). Utilizing computer modeling in the development of a dynamic seating system, RESNA Conference, Reno, NV.

Cooper D, Broughton G. (2001). Dynamic seating and lateral lifts — Clinical and technical perspectives. Canadian Seating and Mobility Conference, Toronto, Proceedings, pp. 59–62.

Siekman, A. (2000). Development and use of dynamic seating for recreational and everyday use. RESNA conference, Orlando, FL.

Wu X., Rakheja S., Boileau, P. (1999). Study of human-seat interaction for dynamic seating comfort analysis, SAE Technical Paper International Congress and Exhibition.
Measurement and analysis of distribution of interface contact force and area under vertical vibration, analyzing cushion design.

Ault, H., Girardi, M. and Henry, C. (1997). Design of a dynamic seating system for clients with extensor spasms. RESNA Conference, Pittsburgh, PA, Proceedings, p. 187-189.
Study found changes in hip extension force and duration using a dynamic back.

Connor PS. (1997). A bit of freedom for full-body extensor thrust: A non-static positioning approach. International Seating Symposium, Pittsburgh, PA, Proceedings, pp. 185–187.
Study found improvements in function, demeanor, and reduced repairs using a dynamic back.

Evans AE, Nelson WB. (1996). A dynamic solution to seating clients with fluctuating muscle tone. RESNA, Salt Lake City, UT, Proceedings. 189–190.
Case Study: Dynamic seat to back angles were custom fabricated to move.

Orpwood, R. (1996). A compliant seating system for a child with extensor spasms. RESNA (p. 261- 262). Arlington VA: RESNA Press.

Riley, K., Levy, B. (1991) A viable alternative for seating children with severe motor dysfunction., 7th Annual International Seating Symposium
A seating system to accommodate to changes in position for a child with constant fluctuations with extension, flexion, and rotation.

Design Articles

Borisoff, J. F., Mattie, J., & Rafer, V. (2013, June). Concept proposal for a detachable exoskeleton-wheelchair to improve mobility and health. In 2013 IEEE 13th International Conference on Rehabilitation Robotics (ICORR) (pp. 1-6). IEEE.
Proposal for a system to combine a detachable exoskeleton and a wheelchair with dynamic seating functions.

Adlam, T. (2012). The Design of Compliant Seating for Children with Severe Whole Body Extensor Spasms. Department of Mechanical Engineering, University of Bath, Bath. PhD Thesis.

Othman, M., Bhuiyan, N., & Kong, L. (2011). Developing a Dynamic Wheelchair Using the Design Structure Matrix Method. Concurrent Engineering, 19(3), 235-243.

V. P. Patrangenaru, (2006). Development of Dynamic Seating System for High-Tone Extensor Thrust, Georgia Tech.

Kitchen, J. (2006). Design of Wheelchair Seating Systems for Users with High-tone Extensor Thrust, Master Thesis, Georgia Institute of Technology, USA.

Duncan, Fernandez, Howard, and Li. (2005). Dynamic Footrest, Georgia Tech.

V. Agrawal. (2005). Characterizing Load Transfer in Variable Positioning Wheelchairs," Georgia Tech.

Ault HK, Girardi MM, Henry CT. (1997). Design of dynamic seating system for clients with extensor spasms. RESNA Press. 187–189.

Patents

Peek, Gregory Alan (2019). Dynamic Seating Components for Wheelchairs. Patent No. 10,463,549.

Peek, Gregory Alan (2016). "Dynamic Seating components for Wheelchairs." U.S. Patent 9,463,123, issued October 11, 2016.

Engman, Bo, Urban Lind, Niklas Backstrom, Jonas Jahkel, and Mehdi Mirzaie (2016). "Wheelchair backrest assembly." U.S. Patent 9,271,885, issued March 1, 2016.

Peek, Gregory Alan (2014). "Dynamic seating components for wheelchairs." U.S. Patent No. 8,888,190. 18 Nov. 2014.

Engman, Bo, et al. (2014). "Wheelchair backrest assembly." U.S. Patent No. 8,636,321. 28 Jan. 2014.

Mammi, Andrea, et al. (2012). Wheelchair dynamic seating system suitable for dystonic disease. European Patent Office, EP2836184B1.

J. L. B. Castillo (2002). Dynamic Footrest. US Patent 2002/0096930 A1

M. Markwald (2002). Traveling Seat. US Patent 6,488,332 B1

S. Farricielli (1999). Ergonomically Designed Seat Assembly for a Portable Wheelchair. US Patent 5,904,398

R. J. Jensen (1999). Dynamic Continuous Passive Motion Chair. US Patent 5,976,097

D. L. Helman (1998). Headrest Assembly with User Actuated Pivotal Support Assembly. US Patent 5,791,735

G. Roth and H. Guenther (1994). Wheel Chair Electric Brake and Pedal Safety Kit. US Patent 5,358,266.

Ayers, Robert and Lee, Ted (1989). Rocking Wheelchair. Patent No. 5004259.

Silverman, Michael (1988). Seating System. Patent No. 5035467A. Pin Dot.
Includes hinge joint at lumbar area which could be locked-out. When the upper portion of the back moved posteriorly in response to client force, the lower portion moved anteriorly.

Ayers, Robert (1987). Wheelchair with rocking seat assembly. Patent No. 4641848. Drive Medical, Canada.

Dunn, Phillip and King, David (1983). Wheelchair with rocking seat and reclining back feature. Patient No. 4544200.

Dalton, John and Lia, Victoria (1973) Folding, Rocking, Posture Adjusting Wheel Chair. Patent No. 3712671, New York.

Secor, Lewis and Secor, Alice (1969). Rocking Wheel Chair. Patent No. 3455600. Los Altos, CA. "The general therapeutic effects of rocking motion are well known. The shifting of weight in the action of rocking provides gentle exercise, assists circulation, and reduces fatigue."

Kiel, Louise (1968) Rocking Wheelchair. Patent No. 3415531. Designed to prevent posterior tipping, added brakes so chair would not roll during rocking.

Kiel, Louise (1965). Rocking wheel chair. Patent No. 3167350A. Newton, Iowa.

Gordin (1968). Stop Means for a recliner chair (non-wheelchair). Patent No. 3371959.

Breuer, Marcek. (1933). Spring Seat. Patent No. 2,084,310.
A stationary chair designed to move in response to movement / force of the occupant.

Wenn and Bishop (1931). Vehicle Seat adjustor. Patent No. 1822427.
Similar design to that found in dynamic seating.

Walker, Charles Francis (1910). Invalid-Chair. Patent No. 961389. Included springs for rocking "giving a more comfortable chair and permit a rocking motion which will overcome the fatigue and ache occasioned by sitting in a straight and rigid chair."

Stern, Harris Wolf (1892). Combined Easy, Rocking, and Invalid Chair. Patent No. 485,435.

A chair to “be utilized as a reclining-chair, a rocking-chair, or a chair for use in nursing the sick, as occasion may demand.” This invention was not designed for use on a wheelchair but was perhaps the first attempt at providing movement in response to client forces and movement.

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Michelle is an occupational therapist with 30 years of experience and has been in private practice, Access to Independence, for over 10 years. She is a well-respected lecturer, both nationally and internationally and has authored numerous texts, chapters, and articles. She is the co-editor of Seating and Wheeled Mobility: a clinical resource guide, editor of Fundamentals in Assistive Technology, 4th ed., NRRTS Continuing Education Curriculum Coordinator and Clinical Editor of Directions magazine. Michelle is on the teaching faculty of RESNA. Michelle is a member of the Clinician Task Force. Michelle is a certified ATP, certified SMS and is a Senior Disability Analyst of the ABDA.