Jennifer Tompkins, PT
April 5th, 2020
Literature Review Evidence Table:

# Postural Control Development: Typical, Atypical, and At-Risk Infants and Toddlers

| Author & Year Research Question(s)/Purpose | Study Design | Participants | Interventions | Outcomes Measures | Results & Conclusions |
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| **Harbourne et al. 2010**[1]<br>Do infants with CP or at risk for CP respond differently to **two different** intervention approaches (one standard of care and the other focused on proprioception, tactile, and pressure information) in comparison to their typically developing peers with the development of independent sitting? | Randomized longitudinal study, clinical trial | Thirty-five infants with delays determined by the score on PDMS-2 of 1.5 SD below the mean correct age assigned to two intervention groups. Comparison group included<br>Fifteen typically developing infants as controls scoring no more than .5 SD below mean on the PDMS-2. | Group 1 (standard of care): 1 x week for eight weeks home program (mean age 15.5months SD= 7)<br>Group 2: 2 x week for 8-weeks (mean age 14.3 months SD =3) perceptual-motor interventions<br>Group 1: The home program consists of family-focused training with caregiver training the primary focus, use of the home environment, and equipment to support sitting, static sitting a focus of intervention. | Intervention Groups:<br>*Center of Pressure Measures* by sitting on a force plate:<br>1. Length Samples of Anterior-Posterior direction.<br>2. Length Samples Medial-Lateral direction.<br>3. A measure of predictability of COP in | - Infants in the Perceptual Motor Group developed COP values closer to typical infants than the Home Program group<br>- Infants in both groups increased their GMFM sitting subscale score by an average of 20 percentage points<br>- COP AP -values increase in variability over time for typically developing infants, along with an increase in regularity = |

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| | | | Group 2: The Perceptual Motor Program is child-led, therapist and child interactions are the focus with child problem-solving sitting posture, dynamic sitting encouraged touch cues to support errors. Continuous exploration by the child encouraged. | the AP direction<br>4. A measure of predictability of COP in the ML direction<br>COP data collected before the intervention and one month after to detect a long-term change in sitting ability.<br>*Gross Motor Function Measure Sitting Section* before and after the intervention period.<br>Control/Comparison Group: | increased postural stability.<br>- Infants in-home program group showed a decrease in COP AP variability and increased in regularity = less exploration in sitting with improved stability (less dynamic)<br>- The typically developing group and the perceptual-motor group demonstrate increased irregularity in the ML direction = improved ability to keep center of mass over the base of support during exploration |

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| | | | | COP data collected the beginning of sitting ability and then three months later. | - The home program group decreased variability in COP ML direction with greater regularity = less complicated strategies in functional sitting.<br>- 20% of infants in the home program crawled by the end of the intervention<br>- 40% of the infants in the perceptual-motor group crawled by the end of the intervention |
| **Harborne et al. 2014**[2]<br>The purpose of this study is to examine the interaction and co- | Longitudinal Prospective Cohort | Twenty-eight typically developing infants and 16 infants with motor delays participated. | No intervention performed. Measures taken at three distinct sitting stages.<br>Stage 1: Prop sit 30 seconds both arms | *Center of Pressure (COP)*: Anterior-Posterior direction (regularity) | - All infant increased stability over time in sitting, as would be expected for infants in that |

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| emergence of upright sitting postural control and look time. Using "Look time" as a measure of cognitive processing, with motor skill development and cognition linked together, the authors hypothesize that look time is not only dependent on neuron maturation but is affected by postural control development. | | All infants were able to prop at least sit for 30 seconds without falling (stage 1 sitting).<br>Typically developing infants were at least 5-months old, no more than .5 SD on PDMS-2.<br>Infants with motor delays were between 6 and 24-months of age, more than 1.5 SD below the mean on the PDMS-2 for corrected age.<br>Exclusion Criteria for both groups was the diagnosis of visual impairment. | without falling, momentary hands-free sitting but returns to prop sitting<br>Stage 2: Sits for 30 seconds without falling and without the use of hands. Reaching and looking around often causes loss of balance — a transitional stage of sitting.<br>Stage 3: Sits for more than 5 minutes without falling. Infant can reach for toys independently with both hands without loss of balance. | Medial-Lateral directions (regularity)<br>*Look Time*: Defined as visual fixing on an object without shifting gaze for more than .5-seconds and looking away is defined as loss of visual fixation more than 1.5-seconds. Objects directly in front of the infant with no other object in view. An average was calculated for all "looks." | stage of development.<br>• Infants with motor delays presented with more regularity and stability in COP anterior and posterior directions, indicating less exploration and discovery of strategies for postural control.<br>• Look time increased at stage 2 of sitting for infants with motor delays compared to typically developing infants who demonstrate a gradual decrease in look time from stage 1 sitting to stage 3 sitting. |

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| | | | | | • The author concludes that look time decreased with increasing sitting stability for all infants, as would be expected. Decreased look time offers opportunities to gather information from the environment, faster, increasing visual information processing. However, for infants with motor delays, look time increased in stage 2 of sitting (hands-free sitting is developing), possibly indicating postural control linked to visual processing. |

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| **Hadders-Algra 2013**[3]<br>The purpose of the paper is to discuss the development of upper extremity reaching ability and its association with postural control development in infant typical and atypical development. | Literature Review | Review of literature included two distinct groups of infants, typically developing and atypically developing. Atypically developing infants included a review of studies on both high-risk and low-risk pre-term infants and those with CP. | No interventions performed | From the review of literature outcomes used to assess postural control included *center of pressure* (COP) measures and *electromyogram amplitude* (EMG) measurements. | Component of typical reaching include:<br>• 4-months of age reaching movements result in grasping with high variability<br>• 4-6-months of age reaching trajectory increases in smoothness with an increase in velocity and decreased corrections needed<br>• 6-months of age and beyond reaching path is straighter and the role of vision increases<br>• 9-months of age and beyond anticipatory control emerges with the increase |

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| | | | | | in somatosensory alpha-band activity.<br>Components of atypical development of reaching:<br>• Low-risk pre-term infants demonstrate initially increased reaching ability at 4-months (supine) and 6-7-months (semi-reclined)<br>• High-risk infants present with delayed reaching/grasping and non-optimal kinematics at 6-months.<br>Typical development of postural control:<br>• Dorsal muscles are active with body sways forward, and ventral muscles are active when |

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| | | | | | the body sways backward.<br>• Postural adjustments that are direction-specific are multisensory coming from 3 inputs: somatosensory, visual, vestibular.<br>• Postural control during reaching relies on anticipatory muscle contractions<br>Atypical development of postural control:<br>• High-risk infants demonstrate delayed postural milestones (ie, sitting upright independent) and demonstrate hyperextension of the neck, trunk, |

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| | | | | | and transient dystonia.<br>• Infants with CP demonstrate decreased sway path, decreased medial-lateral COP measures. Results likely due to increased secondary rigidity in an upright posture and decreased variations of movement in the frontal plane.<br>• Infants with CP have decreased repertoire of adjustments, infants with developmental delay have moderately decreased in adjustments, typical infants have an extensive |

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| | | | | | and flexible repertoire of adjustments, which is linked to increased strategies for postural control in movement. |
| **Kyvelidou et al. 2013**[4]<br>Purpose of this study is to determine if typical infants, per-term infants with motor delays, and infants diagnosed with Cerebral Palsy demonstrate differences on postural control at the emergence of independent sitting (no supports) | Cross-sectional study | Thirty-five full term *typically developing infants*, mean age 5-months (SD .55-months).<br>Six *pre-term infants later diagnosed with CP*, mean age 18-months (4.49-months).<br>Five *pre-term infants with motor developmental delays*, mean age 11.56-months (1.18-months).<br>Inclusion: | Two experimental sessions completed with average of COP measures/scores from both sessions calculated and then compared among the three groups. | *Center of pressure data*:<br>Anterior-Posterior direction (AP)-Linear<br>Medial-Lateral direction (ML)-Linear<br>AP -non-linear LyE<br>ML -non-linear LyE<br>** or LyE = Lyaponuv Exponent and is defined as "measure of the | • Infants later diagnosed with CP demonstrated lower range of AP linear direction values compared to infants both typically developing and those pre-term with developmental delays.<br>• No difference between the 3 groups for ML linear values. |

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| | | • Full-term infant born 37-42 weeks gestation<br>• PDMS-2 score no more than .5 SD from mean<br>• 4-5months of age<br>• Can sit up (with/without hands for support)<br>Exclusion:<br>• Pre-term infants with PDMS-2 score less than 1.5SD below mean<br>• Pre-term infant older than 2<br>• Diagnoses of visual impairment, | | rate at which nearby trajectories in state space diverge.” (cite)<br>LyE can be thought of as “variability” | • Infants typically developing demonstrate higher LyE (AP and ML) values than children with CP.<br>• Children with CP demonstrate lower LyE values in ML direction compared to both infants typically developing and pre-term infants with developmental delays.<br>**Bottom Line**:<br>Infants with CP have less excursion, less variety of movements in the AP direction. These values indicate less freedom of movement secondary rigid spastic postures. Infants with CP |

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| | | hip dislocation or subluxation more than 50% | | | demonstrate lower values in non-linear movements (LyE) AP and ML direction due to decreased strategies during sitting to control COP pressure and therefore have less options for movements in sitting. |
| **Dusing SC, 2016**[5]<br>The purpose of this review article includes;<br>a. Review of evidence around sensory information used in first few months of life<br>b. Discuss how young infants use sensory informatio | Literature review and author commentary | Review of literature with both typically developing infants and pre-term infants with motor delays. | No intervention performed | | Results and author conclusions from studies included the review:<br>1. Variability and errors in movement in early infancy contribute to learning processes and increased strategies for postural control as motor skills develop.<br>2. Postural control is present before upright sitting emerges. |

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| n to modify motor behavior<br>c. Highlight evidence on atypical use of sensory, motor, and postural control in high risk infants born pre-term | | | | | 3. Direction specific muscle activation is present at 3-months of age.<br>4. Postural muscle activation is present with reaching activities at 4-6-months of age<br>5. Lack of variability in early movements and postural control may indicate atypical development.<br>6. Infants born pre-term have less postural complexities in first few weeks of life.<br>7. Infants with less fidgety movements/decreased generalized movements more likely to have |

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| | | | | | diagnoses of CP later in childhood.<br>8. Less infant movement cause less sensorimotor experiences which leads to less opportunity to learn new motor patterns. |
| **Righetto Greco et al. 2019**[6]<br>The purpose of this study is to investigate segmental trunk control difference between full term infants and pre-term infants during the development of sitting. Additionally, this studies purpose is to add new knowledge about segmental trunk | Cross-sectional study | Twenty-six **full term infants** broken into two groups :6 and 7-month-old.<br>Twenty-six **pre-term infants** broken into two groups: 6 and 7-month-old.<br>Inclusion:<br>Full term infants had gestational age between 37 and 41-weeks. Pre-term infants were born | No treatment interventions performed.<br>Infants were evaluated using the *SATCo* and the *AIMS*.<br>Comparisons were made between groups: Spearman r with P=.05 and CI 95%. {r = .26-.49 low, .5-.69 moderate, .7-.89 high, .9-1.00 very high} Effect size was calculated using Cohens d {<.2 = small, >.2 to < .5 = | *Segmental Assessment of Trunk Control (SATCo)*:<br>To determine level of trunk control (cephalocaudal) each infant was tested on a bench sitting with hips and knees at 90 degrees. Static, active, and reactive control were tested segmentally from head to pelvis to determine child's | *Correlation Results*:<br>• SATCo correlated with the supine and sitting sub-sections of the AIMS (p=0.00) and the total AIMS score (p=0.00)<br>• Pre-term infants at *7-months* significant correlations between SATCo and ALL subsections and total score of the AIMS: Prone, |

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| control, supporting new treatments in early intervention to support segmental trunk control along with motor skill development. Authors propose that this study can increase knowledge around how trunk control contributes/influences motor development. | | less than 37-weeks gestation age.<br>Exclusion:<br>Infants with reported sensory or motor impairments, comorbidities associated with premature birth. | moderate, >.5 = large} | level of control. The trunk is broken down into segments: head control, upper thoracic control, mid thoracic control, lower thoracic control, upper lumbar control, lower lumbar control, and full trunk control.<br>*Alberta Infant Motor Scale (AIMS):*<br>Assesses overall gross motor ability in 4 distinct positions: supine, sitting, prone, and standing. Assesses anti-gravity movements, weight bearing, | sitting, total score p=0.00 and supine p=.04 and standing p=.03<br>*Conclusion*:<br>Segmental trunk control is highly correlated with gross motor performance. Acquiring trunk control is critical to functional task performance and affords the infant increased interactions objects and the environment around them.<br>Inter-group results:<br>• Pre-term infants at 6-month-olds demonstrate less trunk control than full-term 6-months old's: Pre-term average SATCo= 2 (upper thoracic control) versus *full-term* 6-month old's |

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| | | | | and postural alignment. | SATCo= 3 (mid thoracic control)<br>Intra-group results:<br>• 23.1% of pre-term 6-month-olds can extend arms in prone and roll prone to supine but without rotation.<br>• **30%** of pre-term 7-month-olds can pivot in prone and roll with trunk rotation<br>• 30.7% of full-term infants at 6-months can extend arms in prone<br>• 30% of full- term 7-month-olds rolling with trunk rotation<br>• **86.6%** of full term 7-month old rolling with trunk rotation |

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| **Saavedra et al. 2012**[7]<br>The purpose of this study is to examine how postural control develops, segmentally during typical development, as the infant acquires independent sitting balance. The study focuses on how the child works against gravity to attain upright trunk control. | Longitudinal prospective cohort | Eight infants participated, from 6-months from age 3 to 9-months.<br>*Inclusion*:<br>• Born full term<br>• No pre, peri, post-natal complications<br>• No known neurologic or musculo-skeletal abnormalities<br>*Control group*: Same data and protocol collected from healthy young adults. | No treatment intervention performed. Participating infants evaluated 2 x per month for 6-months for data collection. | Electromyography (EMG) along with kinematic data collected at 4 distinct points of trunk support given to the infant. An external support device, and a pelvic strap, supported the infant at:<br>1. Axillae<br>2. Midribs<br>3. Waist<br>4. Hips<br>Spinous process C7 was used as an orientation marker.<br>Video recording and kinematic data collected x 3 minutes at each trunk segment. | The data resulted in the following trends during the 6-month data collection period:<br>• Muscle activation and movements changed from erratic to anticipatory in both the anterior-posterior axis and medial-lateral axis.<br>• C7 angles changed with levels of support, and have a U-shape curve to them. Variability of movement increased, then decreased, then increases as trunk stability segmentally improves.<br>• Flexor/extensor muscle pair and |

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| | | | | Muscle activation patterns collected during the 4 different segments of support at each data collection point. | bilateral extensor pairs decreased when lower levels of support are needed. Decreased co-activation in muscle pairs as infant gains upright sitting control.<br>• Stage-like changes of postural control were found on a continuum:<br>Stage one= "slow collapse" – at 3-4 months infant is not able to respond to perturbation and collapses into gravity. No organized muscle activation is present.<br>Stage two= "rise and fall"- infant makes visible attempts to right |

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| | | | | | themselves vertically, then fall away from midline in opposite direction.<br>Stage three = “wobbling”- infant makes postural corrections, wobbling around a set point.<br>Stage four = “upright control” -infant more interactive with environment, spends most of the time aligned vertically, use more range of motion (<variability) than in previous ‘wobble’ stage. |

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| **Pin et al. 2019[8]**<br>The purpose of this study was to examine trunk control from 4-months to 12-months and compare pre-term and full-term infants. Additionally, the authors wanted to investigate how segmental control of the trunk correlated with gross motor development. | Longitudinal Prospective Cohort Pilot Study | *Two groups*: Thirty-one pre-term infants and thirty full-term infants participated in the study.<br>*Inclusion*:<br>• Pre-term infants born less than 30-weeks gestation.<br>• Full-term infants born more than 37-weeks gestation.<br>*Exclusion*:<br>• Known congenital abnormalities, and genetic syndromes in either group. | No treatment intervention performed. In both groups monthly postural assessments using the SATco was performed from 4 to 12-months (corrected age). A gross motor assessment using the AIMS was performed at four, eight, and 12-months of age (corrected age). | Outcome Measures:<br>*SATCo*: sitting postural control tested segmentally from head to pelvis moving from:<br>1. Shoulder girdle<br>2. Axillae<br>3. Inferior scapula<br>4. Lower ribs<br>5. Below ribs<br>6. Pelvis<br>7. No supports<br>*AIMS:* norm-referenced standardized assessment of gross motor development for infant's birth to ~ | The statistical results indicate that pre-term and full-term infants had statistically significant differences in their SATCo scores ($p < .006$) at 4,7,8,9,11, and 12-months of age.<br>As expected SATCo scores increase with age in both groups.<br>Statistically significant differences found between the two groups on the AIMS at 4-months in the supine sub-test and at 12-months in the stand-sub test and the total overall score at 12-months.<br>The SATCo and the AIMS were correlated (Spearman's rho) at:<br>1. 8-months SATCo *moderate* correlation with AIMS supine and sit sub-tests, and total score |

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| | | | | 18-months or onset of independent walking.<br><br>*Both testes were video recorded and a second tester rated each child using the video. | 1. 12-months SATCo *moderate* correlations with AIMS supine subtest (static/active), sit (static, active, reactive), stand (active/reactive), and total score (static/active/reactive)<br><br>*Conclusions*:<br>• Vertical segmental trunk control develops in a cephalo-caudal pattern for all infants.<br>• Static and active trunk control develops before reactive trunk control for full-term infants.<br>• Increasing SATCo level of |

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| | | | | | trunk control takes longer to develop for pre-term infants.<br>• Rapid trunk control develops for full-term infants 6-9 months, with full static/active control by 9-months and reactive control by 12-months.<br>• Pre-term infants develop full active static and active trunk control by 12-months and reactive control is sometime beyond 12-months (study did not go beyond 12-months of age). |

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| | | | | | • Correlation between neutral vertical segmental trunk control and motor skills in supine and sitting suggest that segmental trunk control and motor function are interdependent.<br>• Findings support maximizing therapy and focusing on outcomes that relate to upright trunk control at an early age.<br>• The SATCo allows the clinician to identify the segment at which the infant has attained trunk control or has poor trunk control |

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| | | | | | and target interventions at this segmental level.<br>- Information around trunk control segmental level can support decisions around manually support level or justify use of equipment to support upright sitting. |

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| **Pin et al. 2019**[9]<br>The purpose of this study is to explore the correlations between gross motor skills in prone, supine, sitting and standing in young infants and segmental trunk control. | Longitudinal Prospective Cohort Pilot Study | *Two groups*: Thirty-one pre-term infants and thirty full-term infants participated in the study.<br>*Inclusion*:<br>• Pre-term infants born less than 30-weeks gestation.<br>• Full-term infants born more than 37-weeks gestation.<br>*Exclusion*:<br>• Known congenital abnormalities, and genetic syndromes in either group. | No treatment intervention. Assessments with the SATCO and the AIMS performed at 4,8, and 12-months of age (corrected age) at infant home. | Outcome Measures:<br>*SATCo*: sitting postural control tested segmentally from head to pelvis moving from:<br>1. Shoulder girdle<br>2. Axillae<br>3. Inferior scapula<br>4. Lower ribs<br>5. Below ribs<br>6. Pelvis<br>7. No supports<br>*AIMS:* norm-referenced standardized assessment of gross motor development for infant's birth to ~ | Results:<br>• SATCo static, active, and reactive non-significantly correlated with AIMS scores at 4-months.<br>• Moderate correlation infants at 8-months and 12-months with sitting and standing sub test items.<br>Conclusions:<br>This preliminary data demonstrates correlation of trunk control and motor skill development infants 8 to 12-months. Correlations were considered fair or moderate. Other factors are also at play during this motor skill development time period. Indicates further studies |

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| | | | | 18-months or onset of independent walking. | with kinematic measurements needed to build upon this preliminary data. |
| **Rachwani et al. 2017[10]**<br>The purpose of this study was to examine behavioral flexibility in sitting to various changes in the support surface. Additionally, the authors investigated if | | Twenty-two infants between 6.4 and 8.8-months of age, typically developing and born at term included in the study.<br>*Inclusion*:<br>Infant able to sit in a V-sit for 30-seconds with toy in hands and required | The intervention included testing the infants responds to a movable wooden slope – forward slants and backward slants. Slant of the surface started at 0 degrees (flat) and increased by 2°, for a total of 4-seconds at each increment, until the infant lost balance. The infant's legs were | Outcomes:<br>- Angle of the *trunk to thigh* from starting position (0°), at each 2° angle until infant loses | *Results*:<br>- infant sit on a horizontal flat surface (0°) with a light forward lean, trunk-thigh angles = 70.3° to 88.6°.<br>- Infant age predicted baseline, horizontal trunk-thigh angle. Older infants sat |

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| more experienced sitters had more adaptability or had more stable posture and balance to change in support surface than less experienced sitters (often younger infants). | | no hand support to stay upright. Average # of days from onset of sitting ability = 36.0-days (SD 21.7)<br>*Exclusion*:<br>Born pre-term or with a known medical condition. | in a "V" with arms off the surface. | balance. (video-analyzed)<br>• Steepest slope the infant kept balance at while slope was moving | with trunk closer to 90°, but increased sitting experience did not relate to baseline trunk-thigh angle.<br>• All infants kept balance on slope angle to 18° in the forward direction, and 6° in the backward direction.<br>• Average steepest slope going forward tolerated was 30° (SD =8°) forward, and 19° (SD=8°) backward.<br>• Infants tolerated forward slope better than backward slope.<br>• Forward direction slope tolerance |

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| | | | | | correlated to sitting experience, but not in the backward direction: forward r=.51, p< .032 and backward r=.29, p=.209<br>- Infants adapted their trunk-thigh angle depending on the direction of the slope: increased angle = leaning backward when slope was forward & decreasing angle = leaning forward when slope was backward.<br><br>*Conclusions*:<br>- Infants use reactive control to compensate for |

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| | | | | | perturbation and adapt sitting posture when slope changes.<br>• Infants are more successful at keeping balance when slope is moving forward than backwards.<br>• Postural responses were immediate to the change in slope and incremental, demonstrating visual and proprioceptive pathway use to perceive the slant and respond with trunk/torso adjustments<br>• Even early/new sitters are able to adapt to new novel balance challenges. |

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| | | | | | • Solutions to balance challenges are not “fixed”, rather infants are flexible in their ability to adapt to changes in the surface below them and is an integral part of typical development of upright sitting posture.<br>• Learning to sit is not only about maintaining posture, but rather requires behavioral flexibility. |

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| **Surkar et al. 2015**[11]<br><br>The purpose of this study was to investigate if focused attention during play improves as sitting postural control improves for infants with Cerebral Palsy. An additional purpose was to investigate if impaired sitting postural control affect the development of focused attention for children with CP? | Retrospective experimental cohort | Nineteen children with mean age 21.47-onths (SD= 10.54) diagnosed with mild to moderate CP.<br><br>12-males<br>7-females<br><br>*Inclusion*: Diagnoses of mild to moderate CP using the CP severity scale. Ability to sit with support.<br><br>*Exclusion*: Visual impairments, hip dislocation, other neuromuscular diagnosis, severe cognitive deficits, and quadriplegic CP. | Interventions included perceptual-motor training, or home programing, or body-weighted supported training PT 45-60in 1-2 x per week for 8 to 12-weeks. | All Outcomes:<br><br>All children were assessed with the outcomes below prior to intervention and after<br><br>1. GMFM<br>2. Modified Play Based Assessment (PBA) – focused attention items tagged and coded and measured.<br>3. Sitting subsection of the GMFM pre-intervention, onset | *Results included*:<br>• Mean “longest focused attention” increased changed significantly from 45.04 sec (SD = 22.66) to 57.58 sec (SD =18.68), with $p < .02$ for those who gained independent sitting during the intervention.<br>• Total focused attention time changed significantly from 181.33 seconds (SD= 50.31) pre-intervention to 216.65 (SD= 27.46) post-intervention, with $p < .009$ for all children.<br>• Global focused attention changed for all children |

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| | | | | of sitting to sitting achieved, and then post intervention.<br>4. Global focused attention, longest focused attention, frequency of focused attention was measured at the beginning of onset of sitting (early stage sitting) and then again once | from 3.70 (SD = .97) pre-intervention to 4.27 (SD =.55), $p < .007$. Global focused attention was rated on a qualitative rating scale 1 to 5.<br>- Frequency (# of times) of focused attention decreased for all children 14.18 (SD =3.79) to 13.56 (SD=4.51) from pre to post intervention, with a $p < .8$ and not statistically significant. The authors took out the mobile children and assess the children just sitting, and found significant results: 14.20 (SD 4.27) |

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| | | | | independent sitting had been achieved. | to 12.99 pre to post intervention, with a p < .004.<br>• All GMFM sitting subtest changed significantly from 23.21 points (SD= 8.33) to 38.47 (SD 11.41) pre to post intervention with a p < .001.<br>• Total Focused attention time increased significantly increased from 181.88 to 229.49, with p < .006 seconds for children not independently sitting pre-intervention to independent sitting post-intervention.<br>*Conclusions*: |

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| | | | | | • As sitting postural control advanced focused attention to objects during play increased linearly.<br>• Children who also became mobile, learning to crawl, showed a different trend of focused attention, with more breaks in between attention as mobility increased.<br>• Linear improvement noted in focused attention time and global focused attention for children mobile and those who had learned to sit independent. |

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| | | | | | - Children with CP who were mobile (crawling) had shorter but frequent bouts of focused attention, with increased total duration of focused attention.<br>- Impaired sitting postural control appears related to the development of focused attention, and focused attention appears to increase as sitting postural control improved. |
| **Kyvelidou et al. 2018**[12]<br>The purpose of this study was to examine the effects of altering visual and | Cross-sectional design | Thirteen typically developing infants completed the study. The mean age was 259.69-days (SD 16.88-days). | One experimental session occurred.<br>1. Peabody Developmental Motor Scale-2<br>2. Force plate data | Outcomes included data collection included: Center of Pressure data:<br>a. Mean of linear | Results included:<br>- Main effect (greater values) for the *vision condition* in the AP direction for range |

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| somatosensory inputs on sitting posture in infants. | | 259.69 days = 8.5-months<br>*Inclusion*:<br>• Peabody Gross Motor Quotient score within .5 SD of the mean<br>• Age between 7 and 9-onths<br>• Ability to sit independent without hands (aka stage 3 of sitting)<br>*Exclusion:*<br>• Peabody Gross Motor Quotient of > .5 SD below the mean | collection: infant in sitting - 4 different conditions<br>a. *Control* - sit independent on force plate<br>b. *Somatosensory test*- infant sits on foam pad<br>c. *Visual test*- infants sits while lights are off<br>d. *Combination of b and c.* | anterior-posterior & medial-lateral directions<br>b. Mean of non-linear ApEN and Lye, CoD.<br>c. Linear and non-linear data compared | • Statistically significant greater values in AP direction for vision and somatosensory condition (*d*)<br>• Main effect for the *vision condition* for non-linear LyE in the ML direction<br>• Statistically significant greater values for vision and somatosensory condition for non-linear LyE ML direction<br>**Conclusions/Bottom Line**<br>The results of the study support the idea that vision plays a large role in infant postural control. This study found that in |

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| | | • Diagnoses of visual and hearing deficits<br>• Diagnosed musculoskeletal problem<br>• Acute ear infection or history of chronic ear infection, tubes in ears, or history of dizziness<br>• Medication that could alter balance | | | the lights off condition for both vision and vision/somatosensory conditions, infants presented with increase values in COP measures by increasing range for the AP direction and LyE in the ML direction. A large effect size suggests the change in values is significant.<br>Visual information appears to have a large effect on the infants sitting posture and supports the idea that vision plays a large role in the acquisition of postural control.<br>Altering somatosensory information did not appear to effect infant sitting posture in this study. |

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