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Sit Still and Pay Attention! Trunk Movement and Attentional Resources in Infants with Typical and Delayed Development

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ABSTRACT

Aims: (1) examine infant movement during an early posture (sitting) utilizing a novel video assessment technique; and (2) document the differences between infants with typical development (TD), premature infants with motor delay, and infants with cerebral palsy (CP) during focused and nonfocused attention (NFA).

Methods: Infants were tested when they began to sit independently. We utilized Eulerian Video Magnification (EVM) to accentuate small trunk and pelvic movements for visual coding from video taken during a natural play task with and without focused attention (FA).

Results: Trunk/pelvic movement varied as a function of both motor skill and attention. Infants with TD and CP made fewer trunk movements during periods of FA than NFA. Preterm infants exhibited more trunk/pelvic movement than the other groups and their movement did not differ based on attention type.

Conclusions: The EVM technique allowed for replicable coding of real-time “hidden” motor adjustments from video. The capacity to minimize extraneous movements in infants, or “sitting still” may allow greater attention to the task at hand, similar to older children and adults. Premature infants’ excessive trunk/pelvic movement that did not adapt to task requirements could, in the long term, impact tasks requiring attentional resources.

Video analysis of movement is pervasive, from sports analysis to computer generated actions in popular movies. Video applications for diagnosis and intervention in infants are emerging, but have not yet been introduced to clinical practice (Adde et al., 2010; Kooiene et al., 2015). Although physical therapists are encouraged to use “coaching” techniques during early intervention home visits (Rush & Sheldon, 2011), the advantages of coaching sports using video (Wilson, 2008) have not been extended to pediatric practice. This exploratory study examines a user-friendly video method of quantifying small postural movements during natural activity, such as that encountered in home visits during early intervention. Because early postural control in sitting supports overall development by allowing the infant to expand exploration (Rochat, 1992; Soska, Adolph, & Johnson, 2010), we sought to examine dynamic sitting posture in the context of attention during natural play.

Studies of developing sitting skill describe the process of incremental advancement toward sitting independence between the ages of 4 and 8 months (Hadders-Algra, Brogren, &...
Forssberg, 1996; Harbourne, Giuliani, & Mac Neela, 1993, Harbourne, Willett, Kyvelidou, Deffeyes, & Stergiou, 2010; Rochat, 1992). Rather than displaying the stereotypical quick and anticipatory muscle responses of an older child or adults, infants must build coordinated muscle responses through hundreds of variable trial and error attempts to maintain sitting balance (Harbourne et al., 1993). Newfound sitting independence importantly supports other new developmental activities, such as reaching for desired objects, launching to other positions (crawling), and reorienting (Soska, Robinson, & Adolph, 2015). As infants acquire strategies to stabilize and adapt their sitting, they learn to interrupt visual attention, shift gaze, and process visual information, which in turn supports event predictions, understanding the properties of objects, and differentiating foreground from background (Bertenthal, Longo, & Kenny, 2007; Harbourne, Ryalls, & Stergiou, 2014; Lefevre, 2002; Ross-Sheehy, Perone, Vecera, & Oakes, 2016).

Maintaining an upright posture such as sitting while performing a functional cognitive task requiring attention may challenge the movement system, depending on the complexity of either the motor task or the cognitive component of the task (Bernard-Demanze, Dumitrescu, Jimeno, Borel, & Lacour, 2009). The strategy of reducing postural sway in order to focus on a suprapostural task is documented in older adults (Verghese et al., 2007), children (Haddad, Van Emmerik, Wheat, & Hamill, 2008), and children with cerebral palsy (CP; Schmit, Riley, Cummins-Sebree, Schmitt, & Shockley, 2016). Attention demands the allocation of fixed mental resources; thus, as more attention is required by one component (posture), less attention can be allocated to the cognitive task, limiting cognitive performance. Conversely, intense cognitive focus may alter motor strategies (Warburton, Wilson, Lynch, & Cuykendall, 2013, p. 2), such that reducing and minimizing movement can yield cognitive benefits, such as memory. Importantly, the interaction of the motor and cognitive systems emerges during early intervention and can be supported through therapeutic means (Morgan, Novak, Dale, Guzzetta, & Badawi, 2016).

This interaction of motor and cognitive systems can be seen in infants who are preterm, who display delayed adaptive postural control early in life, resulting in delays interacting with objects even prior to sitting (Dusing, Thacker, & Galloway, 2016). Children who were very preterm notably continued to display deficits in postural control as they grew, with four-year-old children showing longer center of pressure (COP) path length during both dynamic and static standing than their typically developing peers, particularly during a concurrent cognitive task (Lorefice et al., 2015). Thus, it appears that solving early motor problems requires attentional resources to support both the motor skill and the cognitive task (Boudreau & Bushnell, 2000; Shinskey & Munakata, 2005).

A cognition–action tradeoff as sitting emerges is particularly significant for children with early motor delays because the attention required for a difficult motor task may come at the expense of cognitive efforts (e.g., Berger, 2004; Berger, 2010). High-risk infants explore less often very early in life and their exploratory behaviors are less variable, with fewer combinations of behaviors than those of typically developing infants (e.g., Kaur, Srinivasan, & Bhat, 2015; Libertus, Sheperd, Ross, & Landa, 2014). Furthermore, high-risk infants tend to perform few behaviors while interacting with objects, rather than matching manipulation behaviors to object properties, thus missing information about the unique properties of objects (Lobo, Kokkoni, Cunha, & Galloway, 2015). Infants with motor delays tend to look longer at objects than their typical counterparts during sitting development (Harbourne et al., 2014). These longer looks may be related to the need for longer processing time to pick up information
while performing the difficult task of maintaining a new position. Infants with CP and resulting delays in achieving sitting showed increased focused attention (FA) as they developed independent sitting, possibly due to the greater stability of the body allowing more resources for attention (Surkar, Edelbrock, Stergiou, Berger, & Harbourne, 2015).

These cognition–action tradeoffs during the execution of novel motor behaviors have implications for infants who repeatedly go through the process of acquiring new motor milestones during the first year. Namely, how does the competition between effortful motor behavior and other activities that demand attention shape behavior as mastery fluctuates during motor milestone onset in infancy? FA is a phenomenon indicative of cognitive processing that is measurable in infants (Lawson & Ruff, 2001). Previous work with infants indicated that FA improved as sitting became more independent (Surkar et al., 2015). FA in infants looks very similar to FA in older children; the infant has long looks to a closely regarded object, without moving into different positions or being distracted by external stimuli (see methods for further definition). Because infants do not have fine motor skill to perform the usual tasks used as a cognitive load for older children, we utilized naturally occurring periods of FA as novel toys were presented to the infant.

The importance of noting a lack of small generalized movements in infants are notably a marker for motor deficits (Adde, Rygg, Lossius, Øberg, & Støen, 2007). Clinically, the gestalt observation of generalized movement quality as an indicator of future motor deficits requires special training for recognizing and discriminating normal vs. abnormal movement (Hadders-Algra, 2004). Because small general movements have proven to be important in early diagnosis of motor disorders, we sought to utilize the observational method of tallying small trunk/pelvic movements as an indicator of motor skill in sitting, utilizing a video processing method to magnify movements for easier identification. Eulerian video magnification (EVM), used to reliably amplify video to detect pulse frequency for health data, was our choice to assist in counting small movements (He, Goubran, & Liu, 2014).

Many seemingly static scenes contain subtle changes that are invisible to the naked eye (Wu et al., 2012). However, it is possible to highlight these small changes to reveal previously hidden movements using EVM software developed by the Massachusetts Institute of Technology’s Computer Science and Artificial Intelligence Laboratory (Wu et al., 2012). EVM has the advantage over traditional motion analysis equipment of being inexpensive and easy to use. It has been used to measure subtle changes on video such as breathing movements in infants, and heartbeat in the faces of adults (https://www.youtube.com/watch?v=e9ASH8IBJ2U). We asked whether EVM was sensitive enough to serve as a tool for addressing basic questions of stability during sitting development in infancy.

**Aims of the Study**

Toward our overall goal of examining the usefulness of a novel video technique to examine movement and attention in infancy, we had three aims. Our first aim was methodological—we examined whether EVM was a feasible tool for accentuating small movements and allowing visual coding of sitting stability in a natural setting.

Our second aim was to test whether the trunk/pelvic movements of typically developing infants differed from infants who were motor delayed due to CP or prematurity. Given premature infants’ tendency toward disorganized patterns of movement and attention (Dusing et al., 2016; Hadders-Algra, 2013), we expected their movements overall to differ from the typical development (TD) infants, but did not have a priori expectations about the extent or
direction to which they would differ. Because children with CP may have decreased movement variability, excursion, and speed, we expected that they may have fewer trunk/pelvic movements overall than the other two groups (Adde et al., 2010).

Our third aim was to test for differences between infants’ overall movement during FA and nonfocused attention (NFA). We expected infants to minimize trunk/pelvic movement during bouts of FA because overall stability (less movement) facilitates infants’ exploration and learning (Claxton, Strasser, Leung, Ryu, & O’Brien, 2014).

Method

Participants

Criteria for participation was the ability to sit independently, not yet able to crawl, and not yet moving in and out of sitting. A highly trained experimenter interviewed parents about infants’ sitting ability during recruitment for the study, which was then confirmed in the lab using a sitting skill assessment (Harbourne & Stergiou, 2003). All infants could sit at least 10 seconds without propping. Skill was held constant with age allowed to vary.

Infants Born Full-Term. Twenty-two typically developing infants (13 boys) between the ages of 6 and 8.5 months participated. All were healthy and born at term, between 38 and 42 weeks gestation. Participants were recruited via fliers distributed around the community, birth announcements from the local newspaper, and representatives from the lab attending events aimed at families with young children held at local libraries and the local children’s museum.

Most families from the typically developing infants were Caucasian (50%) and the remainder were either African American (5.60%), mixed ethnic/racial backgrounds (11%), or did not answer (33.3%). Approximately 56% of infants had one or more parent with at least a college education, 2% had parents with a high school degree, and 42% did not answer. Approximately 62% of families had both parents employed, 11% had at least one parent who was a homemaker, and 27% chose not to answer the question. Parents gave informed written consent prior to the study.

Infants with CP. The data from infants with CP and infants born premature were obtained from archival video collected during two prior studies examining the development of sitting and play (Harbourne, Kurz, Willett, Capoun, & Surkar, 2015; Ryalls et al., 2016). Nine infants (6 boys) between the ages of 12 and 30 months with a diagnosis of CP participated. Infants in this group received early intervention services or physical therapy due to motor delays. A physician or pediatric neurologist performed a diagnosis for infants with CP as part of their overall medical care. Table 1 shows characteristics for this group, including severity by Gross

<table>
<thead>
<tr>
<th>Subject #</th>
<th>GMFCS level</th>
<th>CP type</th>
<th>Age (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>II</td>
<td>Spastic right hemiplegia</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>III</td>
<td>Spastic quadriplegia</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>III</td>
<td>Spastic quadriplegia</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>III/IV</td>
<td>Spastic quadriplegia</td>
<td>14</td>
</tr>
<tr>
<td>5</td>
<td>III</td>
<td>Spastic triplegia</td>
<td>16</td>
</tr>
<tr>
<td>6</td>
<td>I</td>
<td>Spastic diplegia</td>
<td>10</td>
</tr>
<tr>
<td>7</td>
<td>I</td>
<td>Spastic right hemiplegia</td>
<td>9</td>
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<td>8</td>
<td>II</td>
<td>Spastic diplegia</td>
<td>12</td>
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<td>9</td>
<td>II</td>
<td>Spastic right hemiplegia</td>
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Motor Functional Classification Scale (GMFCS; Palisano et al., 2008), type of CP and age. Six children were Caucasian, one was African American, and two were mixed race.

**Infants Born Premature.** Seven preterm infants (five boys) between the ages of 11 and 17 months participated. Infants in this group were born between 34 and 36 weeks gestation and all but one were receiving physical therapy for motor delay of at least one standard deviation below normal for their age for gross motor skills as measured by the Peabody Developmental Motor Scales (Folio & Fewell, 2000). Six infants were Caucasian and one was mixed race. To recruit infants who were preterm or had a diagnosis of CP, employees of the University of Nebraska in Omaha and Munroe-Meyer Institute of the University of Nebraska Medical Center referred families who came for services to a PI of the study.

**Procedure**

**Materials.** Three toys were chosen for each infant at random from a possible five and presented in random order. Toys included a pop-up pals toy (17.3 cm × 29.1 cm × 5.6 cm), transparent plastic balls with small items inside that moved or rattled (2.43 cm × 12.19 cm), 10 piece set of stacking cups (ranging from 2.86 cm × 6.35 cm to 5.40 cm × 7.62 cm), three chained plastic rings (15.2 cm), and a toy gumball machine (33.27 cm × 28.45 cm × 17.78 cm).

**Focused Attention Task.** We carried out the FA task as described in Lawson and Ruff (2001), with one important modification: because we were interested in sitting control as it related to attention, all infants sat independently upright on the floor during the task, rather than in a parent's lap or in a high chair (Thomas et al., 2012). Infants received three toys in succession to explore for 90 seconds each (see Figure 1). Toys were placed on the floor in front of the infant. Trials began when infants retrieved the toy and ended after 90 seconds of exploratory play. During this time, parents were not in direct view of the infant. Parents were asked to refrain from engaging with infants during trials. All sessions were videotaped for later data coding. To ensure that infants' facial expressions, body movements, and toy manipulation were captured on video, a research assistant positioned a single camera on the floor facing participants so that their bodies filled the frame.

**Eulerian Video Magnification**

We randomly selected and edited three 10-second independent sitting segments each of FA and NFA from each 90 second trial where the infants showed no indication of loss of

![Image of infant exploring a toy](image1.png)

**Figure 1.** Infant exploring a toy during a bout of focused attention in the natural play task. Camera angle ensured coders could detect trunk movement from the magnified video.
balance, yielding six segments per infant, for a total of 228 segments. Using Matlab to specify the spatial and temporal parameters of interest, we processed the videos of the FA task using a Butterworth filter from 0.5 to 10 Hz, which is a range able to exaggerate “visible, yet subtle” motion (Wu et al., 2012, p. 6). The EVM algorithm decomposes standard video input into different spatial frequency bands, applies temporal filtration, and amplifies the resulting signal up to 100 times (see http://people.csail.mit.edu/mrub/evm/#code for several examples of source and amplified videos). The system works by analyzing each pixel for variations over time, then magnifying that variation. Background items that do not change are not identified, whereas specific pixels showing minute frame-by-frame changes in color are identified and amplified. Video can also be processed online at https://lambda.qrilab.com/site/, which does not require access to Matlab for coding.

**Data Coding**

A primary coder scored outcome measures from each trial using Datavyu digital video coding software (datavyu.org). Datavyu has keyboard commands that control and record durations and frequencies of behaviors of interest.

*Duration of FA and NFA.* From unprocessed video using Datavyu, we identified the frame marking the onset of a FA or NFA bout and the frame marking the offset of that bout, and calculated the duration between those frames. Sustained and concentrated FA is marked as when an infant looks “steadily at the toys with a serious and intent expression, reduces the distance between toy and self for better inspection, quiets other body movements, and seems to lose awareness of self with no vocalizing and no social bids” (Lawson & Ruff, 2001, p. 297). NFA is marked by looking away from the toy, relaxed facial expression, vocalizations, and extraneous body movements. Behavioral measures of attention including steadiness of gaze, facial expression and affect; position of toys relative to eyes; self-consciousness; amount of extraneous movement of all body segments, including head and extremities (visible to the naked eye in real time in an unaltered video) are used to identify FA and NFA, but are not coded individually (Lawson & Ruff, 2001).

*Trunk and Pelvic Movement.* The second outcome measure coded from video using Datavyu was infants’ trunk/pelvic movement. From the segments of magnified video, coders tallied the number of forward-, backward-, and side-to-side from-center movements when infants were sitting upright independently during FA and NFA and as an independent measure from the movements used to categorize attention. Motor adjustments performed when infants were leaned over, supporting themselves on caregivers, objects, or the floor were not counted. These small trunk/pelvic adjustments are not identifiable in standard video because they are too subtle to be caught by the naked eye; they include pelvic tilt movements, which alter the shape of the trunk in sitting. When we could not find 10 consecutive seconds (approximately 13% of all bouts), we normalized the tally of trunk/pelvic movements from the longest segment we could code to 10 seconds. A 2 (FA vs. NFA) × 3 (TD vs. PT vs. CP) ANOVA on duration of bout of attention with attention type as a within-subjects factor and group as a between-subjects factor revealed no main effects for attention type or group, confirming that infants contributed equivalent segment durations for analysis and that motor skill did not impact their ability to sustain attention (mean bout durations were FA TD = 9.61, SD = 1.22; FA PT = 9.81, SD = 1.01; FA CP = 10.09, SD = 0.21; NFA TD = 9.54, SD = 1.32; NFA PT = 9.25, SD = 1.75; NFA CP = 9.72, SD = 1.37).

*Reliability.* A primary coder coded all variables from video. To calculate interrater reliability, a second coder independently coded 30% of all trials selected at random. Both coders were blinded to the group assignment of the infants. The coders were naïve to possible motor signs
Figure 2. Effect of group and attention type on infants’ trunk movement. Height of the bars indicates the number of movements in each 10 second bout of focused (gray bars) and nonfocused (black bars) attention. Error bars represent standard error.

Results

Because our sample sizes were small, there was a question of the appropriateness of using parametric analyses. Shapiro-Wilk tests of normality confirmed that for both FA and NFA conditions, both TD (SW(22) = 0.95, p = 0.30 and SW(22) = 0.98, p = 0.92, respectively) and CP samples (SW(9) = 0.95, p = 0.73 and SW(9) = 0.99, p = 0.99, respectively) were normally distributed. Because four of our six groups were normally distributed, we proceeded with parametric analyses.

A 2 (FA vs. NFA) × 3 (TD vs. PT vs. CP) ANOVA on trunk/pelvic movements with attention type as a within-subjects factor and group as a between-subjects factor showed significant main effects for attention type, $F_{(1, 35)} = 19.22, p < 0.01, \eta_p^2 = 0.35$, and group, $F_{(2, 35)} = 6.36, p < 0.01, \eta_p^2 = 0.27$ (see Figure 2).

Planned comparison $t$-tests revealed significant differences between FA and NFA for infants in the TD and CP groups (all $p$’s < 0.01), with both groups moving more in NFA than FA, but no difference in trunk/pelvic movements between the conditions for the PT infants. During FA, all three groups differed significantly from each other: infants with CP (mean trunk/pelvic movements = 3.05; SD = 0.99) moving least and premature infants (mean trunk movements = 7.38; SD = 5.87) exhibiting the most trunk/pelvic movement (all $p$’s < 0.05; TD mean trunk/pelvic movement = 4.40; SD = 1.13). During NFA, premature infants (mean = 8.12; SD = 3.60) exhibited significantly more trunk/pelvic movement than infants in the TD (mean = 5.84; SD = 1.41) and CP groups (mean = 4.99; SD = .99; all $p$’s < 0.03).

Discussion

Using a posture-held constant design, this study examined trunk/pelvic movements during sitting using EVM during periods of FA and NFA in typically developing infants, infants born prematurely, and infants with CP. Trunk/pelvic movement varied as a function of both motor skill and attention. The movement of premature infants differed from that of the full-term
infants and infants with CP: premature infants exhibited more trunk/pelvic movement than the other groups and, unlike the other groups, the trunk/pelvic movements of premature infants did not differ based on whether attention was focused or not. In contrast, TD infants and infants with CP moved their trunk/pelvis less during periods of FA than NFA. The EVM technique allowed for replicable coding of small trunk/pelvis movements in sitting infants and made real-time “hidden” movements from standard video become visible for analysis in the converted EVM video.

Infants with CP may prioritize stability of the head and trunk by exaggerating motor control strategies (increasing excursion, speed, or force of movements), and thus alter or reduce reaching and exploring novel objects as postural challenges occur (Ju, Hwang, & Cherng, 2012). Alternatively, the ability to decrease trunk movement in order to attend to a task would be consistent with the strategy adopted by both older children with TD and older children with CP in standing (Schmit et al., 2016), as well as the infants born full term in this study. Minimizing small movements of the trunk, or “sitting still” may allow the allocation of attention to be prioritized for the exploratory task at hand.

Premature infants’ excessive trunk movement may reflect deficits in postural control, which could, along with visual-motor deficits that occur in a percentage of children born prematurely (Geldof et al., 2016), eventually impact tasks requiring attentional resources. Because duration and frequency of FA bouts did not differ between the three groups, movement differences in the premature group raise a question about the quality of that attention, namely whether premature infants are accessing the same type and quantity of information as other infants. This fundamental difference at the outset of exploratory behavior in infancy, or possible lack thereof, may serve to partially explain developmental mechanisms underlying later attention deficits associated with preterm birth (Reuner, Weinschenk, Pauen, & Pietz, 2015).

When infants with motor impairments begin to sit, their control strategy differs from TD infants, suggesting that they may have missed an early window of opportunity to interact with the world that can later delay learning and cognition (Babik, Galloway, & Lobo, 2017). In this exploration of the EVM method, trunk movements of sitting infants could be noted without special equipment, in a natural play situation, with acceptable reliability. The reliability of coding the trunk movements was, in fact, higher \( r = 0.83, p < 0.01 \), considered good) than standard methods of measuring postural sway using a force platform, which ranged from poor \( (ICC = 0.00) \) to fair \( (ICC = 0.74) \) in a reliability study of sitting infants (Kyvelidou, Harbourne, Stuberg, Sun, & Stergiou, 2009).

The EVM methodology may be useful in early intervention to provide a measure of changing movement strategies over time. Moreover, EVM revealed a unique pattern of extraneous movement during focused attention in premature infants that may not have been detected using the standard FA coding scheme (Ruff, 1986; Thomas et al., 2012). The use of standard video, accessible to everyone via smartphone or other digital devices, could potentially provide quantification of small movement deviations that could indicate attentional focus in infants or children who are challenging to evaluate. Thus, this technology suggests that a deeper exploration into the validity of FA measures in atypical populations may be warranted and may also be feasible using EVM.

**Limitations**

This was a cross-sectional study to probe the interacting factors of attention and movement control during the attainment of independent sitting. Longitudinal studies would provide a greater understanding of attention allocation as new motor skills emerge and help to clarify
group differences as indicative of developmental delays or alternate developmental trajectories. In addition, our groups of infants with CP and prematurity were small, and may not be representative of these widely variable diagnoses. The infants with prematurity in our study had motor delays, and may not be representative of premature infants who do not exhibit delays. Additionally, our infants with CP were young, with the possibility that motor symptoms could resolve as they matured.

Using a skill-held constant design that allowed age to vary may have been another limitation. Infants diagnosed with or at risk for motor delays, such as the infants in the CP and PT groups, met the postural criteria for participation when they were older than the TD infants. It is possible that the age difference could have influenced the findings based on differences in attention. However, a number of studies have shown motor skill to have more explanatory power than age on behavior in typically developing infants (e.g., Berger, 2010; Berger, Cunsolo, Ali, & Iverson, 2017; Karasik, Tamis-LeMonda, & Adolph, 2011). Future work would do well to tease apart these factors, paying special attention to populations with atypical motor development.

Clinical Implications

The EVM technique for exaggerating movement appears to be a reliable and clinically feasible method to estimate trunk movement, and thus motor control, in a noninvasive way that is particularly attractive for use in natural settings with infants. Although the technology is not easily available for clinicians at this time, it is freely available with a web-based application, and one can envision a user-friendly smartphone app in the future. Many uses are being found for this amplification technology, as noted by scientists examining subtle changes in both animate and inanimate subjects of interest (see TED talks such as: https://www.ted.com/talks/abe_davis_new_video_technology_that_reveals_an_object_s_hidden_properties).

Conclusions

The findings of this study add to existing evidence that the control of movement merges with cognitive tasks in ways that may be significant for infants with special needs. Understanding the interaction of attention as a child builds a new motor skill can lead to important approaches to early intervention, and should be considered by teachers, therapists, and families as a means to help advance overall development. Clinically, video is accessible and user-friendly, and could be used to document change over time, as well as provide a quantifiable measure, through the use of EVM, for movement analysis. Therapists using a coaching model would be able to clearly show families subtle changes in movement that may be difficult to explain with only verbal information or static pictures.

Declaration of Interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

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Regina T. Harbourne is a pediatric physical therapist and researches the efficacy of early intervention for infants with motor delays. She received her PhD in Developmental Psychology, and is an assistant professor in the physical therapy department at Duquesne University.

Carmen L. Guallpa Lliguichuzhca received a Bachelor of Science in Psychology from the College of Staten Island in 2016. She plans on attending graduate school to become an occupational therapist.

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