Movement Analysis—An Aid to Early Diagnosis of Cerebral Palsy
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Movement Analysis—An Aid to Early Diagnosis of Cerebral Palsy

The purpose of this article is to review research related to the use of clinical analysis of movement as an aid to the early diagnosis of cerebral palsy. A historical perspective of clinical techniques used by physicians and physical therapists in the early diagnosis of cerebral palsy will be presented first, including recent research findings on clinical signs that were most predictive of this movement disorder. Predictive neuromotor behaviors common across several recent studies will be highlighted. Future trends in the use of movement analysis, including digitized kinematic analysis of term and preterm infants and fetal ultrasound techniques, will be discussed as well. [Harris SR. Movement analysis—an aid to early diagnosis of cerebral palsy. Phys Ther. 1991;71:215–221.]

Key Words: Cerebral palsy; Kinesiology/biomechanics, general; Movement; Pediatrics, development; Pediatrics, evaluation.

The purpose of this article is to review research related to the use of clinical analysis of movement as an aid to the early diagnosis of cerebral palsy (CP). A historical perspective of clinical techniques used by physicians and physical therapists in the early diagnosis of CP will be presented first, including recent research findings on clinical signs predictive of this movement disorder. Future trends in the use of movement analysis as an aid to the detection of CP will be discussed as well.

Historical Perspective on Early Diagnosis of Cerebral Palsy

The most universally accepted definition of CP was provided by Bax in 1964: “A disorder of movement and posture due to a defect or lesion of the immature brain.” Bennett has further defined CP as a nonprogressive disability resulting from damage or defect in the brain that occurs during the period of rapid brain growth—either prenatally, perinatally, or up to 3 to 5 years following birth. Classification of the different types of CP has been based historically on predominant neurological signs, including abnormalities in muscle tone and extrapyramidal functions. Barabas and Taft have listed six different types of CP using this form of classification system: spastic, choreathetoid, ataxic, dystonic, hypotonic/ataxic, and mixed; spastic CP has been further classified by the limb involvement as either quadriplegia, hemiplegia, or diplegia. The value to physical therapists of such a medically oriented classification system has been questioned by Sahrmann, who has suggested that physical therapists themselves must classify or categorize, by specific assessments, the components of the movement dysfunction that will provide definitive guidelines for treatment and for a prognosis.

For example, physical therapists are beginning to use kinematic data to quantitatively describe movement in children with CP with the goal of developing specific guidelines for treatment.

Descriptive Literature on Early Diagnosis of Cerebral Palsy

Until the late 1970s, most of the literature on the early diagnosis of CP was based on clinical impressions of neurologists, pediatricians, and physical therapists who had acquired extensive experience in evaluating children with this developmental disorder. Emphasis was placed on the assessment of muscle tone, absence or persistence of primitive or postural re-
Muscle tone has been defined traditionally as resistance to passive elongation or stretch in the assessment of infants at risk for CP, tone has been differentiated further as active tone or passive tone. As Wilson has noted,

Active tone is defined as the power and adaptability of the muscles during spontaneous movement, and passive tone refers to resistance of the muscle when movements are imposed by the examiner.

The historical emphasis on primitive reflexes as diagnostic markers for early CP raises interesting questions about the role of infant reflexes in development. Oppenheim, in citing the work of McGraw, Peiper, and Touwen, has commented that infantile or primary reflexes "typically disappear within the first year or so of life." Easton, however, has suggested that reflexes "form the basic language of the motor program" and underlie most, if not all, volitional movements. In attempting to diagnose CP during infancy, child neurologists and developmental pediatricians have concerned themselves primarily with the persistence or exaggeration of primitive reflexes.

Contradictory views on the prognostic importance of the various primitive reflexes among experts in the field of neuromotor assessment prompted the following comments from Scherzer, a leading developmental pediatrician:

The literature is replete with differing views of the significance of early reflex behaviors. For example, St-Anne-Dargassies ... places little importance on the Galant reflex, but considers crossed extension to be critical in maturation. Taft ... stresses the predictive significance only of the asymmetric tonic neck and crossed extension reflexes. Our own clinical experience of predictability has led to the use of the following reflexes: Moro, palmar grasp, rooting, sucking, and asymmetric tonic neck. The postural reflexes we emphasize include neck and body righting, parachute (protective extension), and Landau. ... Delineation of which reflex behaviors have the most reliable predictive value would be a major contribution, worthy of extensive study by any research group.

As Scherzer noted in his concluding comment, it is only through systematic research efforts, both retrospective and prospective, that real clues to the early diagnosis of this disorder can be uncovered. Fortunately, database studies conducted during the past two decades have begun to identify important clinical signs that can be used in the early identification of CP. Unfortunately, there has been little attempt to summarize or consolidate these findings in order to identify commonalities across these studies. As a result, those movement behaviors that are most predictive of CP are just beginning to be identified. The goal of the following section is to provide a summary of those findings.

Research Findings on Early Diagnositic Signs of Cerebral Palsy

In a descriptive study of 1,743 term newborn infants, Amiel-Tison and colleagues examined the importance of neck extensor hypertonia as a clinical sign of insult to the central nervous system. This study was based on the clinical impressions of the authors that there was an association between increased neck extensor muscle tone and perinatal insult to the central nervous system.

Six procedures were used to examine active and passive tone of the neck. Initially, the infant's neck position was observed with the infant positioned supine in order to evaluate the presence of spontaneous hyperextension. The infant's head was passively flexed four times to determine whether there was increasing resistance to passive flexion. With the infant still lying supine, the examiner then attempted to provoke opisthotonus by lifting the infant slightly between the neck and scapulae. Active flexor and extensor tone of the neck were assessed by pulling the infant into a sitting position from the supine position and by then pushing the infant smoothly back into a supine position. The examiners observed the infant's ability to co-contract flexor and extensor muscles. By rocking the infant backward and forward in supported sitting, the examiner assessed the "equality of tone" of the flexor and extensor muscles. Normal and abnormal reactions were described for each of the procedures; infants were considered to show neck extensor hypertonia if they demonstrated abnormalities in both active and passive tone.

There were 57 infants who showed neurologic abnormalities beyond the first 3 days of life. For example, disturbances such as tone or reflex disturbances, irritability, and seizures were noted. Of those 57 infants, 47% had neck extensor hypertonia. Of 31 infants with transient neurological signs (less than 3 days), 6% showed neck extensor hypertonia, whereas only 0.7% of the remaining 1,655 neurologically normal infants showed neck extensor hypertonia (for 1 day).

The prognostic significance of neonatal extensor hypertonia among this sample of term infants was questionable because only 5 of the 43 infants followed to the age of 1 year showed persistent neurological abnormalities. The authors stressed the need, however, to conduct future studies with follow-up at least until school age. They also emphasized the danger of examining individual neurological signs in isolation.

This was a descriptive study with limited prognostic value; however, it represents one of the earliest attempts to systematically document the presence of specific neurological signs by using a standardized assessment procedure. Later studies have corroborated the importance of neck extensor hypertonia as an important diagnostic sign for the early identification of CP.

In 1981, Ellenberg and Nelson published the results of a retrospective study that examined the relative value of certain physical findings and behavioral responses of 4-month-old infants in predicting CP at early school age.
Because the study was part of the Collaborative Perinatal Project of the National Institute of Neurological and Communicative Disorders and Stroke, the sample consisted of approximately 32,300 infants who were examined at 4 months of age and then again at 7 years of age. Diagnoses of CP were made, as appropriate, at the examination at age 7 years. The predictive value of physical and behavioral measurements at 4 months of age was analyzed by using corrected chi-square statistics to demonstrate the incidence of children who showed each behavior versus children without the behavior. Predictive behaviors were examined for "low birth-weight" infants (≤2500 g) as well as for "term birth-weight" infants (>2500 g). Relative risk was defined as the number of times more frequently CP occurred among children with a given characteristic compared with those without that characteristic.21

Movement behaviors found at 4 months of age that were associated with an increased risk for CP among the low birth-weight infants in the sample included tremulous or jittery patterns of movement. In the term birth-weight infants, writhing movements were associated with later CP. Asymmetrical movements were not predictive of CP in general or of hemiplegic CP in either birth-weight group.

Specific developmental milestones were associated with an increased relative risk for CP. These developmental milestones included the infant's failure to maintain hands open, to support weight on the forearms in the prone position, to hold the head erect in supported sitting, or to engage interest in her or his mirror image. These behaviors were associated with relative risks of 4, 12, 15, and 17, respectively. Muscle tone abnormalities at age 4 months were strongly related to later CP, with neck and trunk hypertonia being of even greater relative risk (74 and 71, respectively) than hypertonia in the limbs (55 in the arms and 52 in the legs). Hypertonia was associated consistently with greater relative risks than hypotonia, particularly in the low birth-weight infants.21 The finding that neck extensor hypertonia at age 4 months was associated with a 74-fold increase in later CP supported the contention of Amiel-Tison and colleagues that this is an important diagnostic marker for central nervous system insult.

Because Nelson and Ellenberg22 previously studied prognostic indicators of CP among newborn infants in this same sample, they concluded that neck extensor hypertonia at 4 months of age was an even greater cause for concern than neck extensor hypertonia during the neonatal period. Whereas the presence of this sign was followed by later CP in 4% of the term birth-weight neonates but in none of the low birth-weight neonates, 15% of term 4-month-olds and 42% of low birth-weight 4-month-olds who demonstrated this sign received later diagnoses of CP.21 This sign was absent in 99.9% of infants who did not develop later CP.

In 1983, Touwen and Hadders-Algra23 published a prognostic study of the effects of neck and trunk hyperextension and shoulder retraction in infancy on neurological outcome at 18 months of age. Their sample consisted of 105 infants, all of whom showed hyperextension of the neck and trunk with shoulder retraction at an initial examination conducted during the first few postnatal months; thus, comparison of their results with those of Ellenberg and Nelson21 or with those of subsequent studies24 is not really possible. Although most researchers agree that no single neurological sign is predictive of later CP, statistical analyses can at least measure the relative effectiveness of different signs, with the goal of improving prediction in subsequent prospective studies. The focus by Touwen and Hadders-Algra23 on an isolated neurological

The final follow-up visit in Touwen and Hadders-Algra's23 study was conducted at approximately age 18 months or when the infant could walk independently. Of the 38 infants with no additional neurological signs, 37 were neurologically normal at the last follow-up visit, and 1 was classified as "suspect," which indicated the presence of "mild neurological signs, such as mild hypotonia or slight hyper-tonia."23(202) For the 45 infants labeled initially as mild, 23 developed normally, 21 were deemed suspect, and 1 was severely impaired. Of the remaining 22 infants, who had been classified as marked during the early months postnatally, 20 were severely impaired and 2 were identified as suspect at the final follow-up visit.

Based on these findings, the authors concluded:

Hyperextension and shoulder retraction in neonatally neurologically normal infants appeared to be without much clinical significance, even when some slight additional neurological abnormality is present.23(p202)

Nonetheless, the fact that 42.8% of infants identified initially because of this sign were subsequently labeled as either suspect or abnormal at about 18 months of age suggests that this sign is an important diagnostic predictor of neurological dysfunction, especially if found in combination with other neurological signs. The authors did not statistically analyze the relative risk for having this sign or any of the other neurological findings during the first few postnatal months; thus, comparison of their results with those of Ellenberg and Nelson21 or with those of subsequent studies25 is not really possible.

marked, when evident signs of hypertonia, hypotonia, hemisyndrome or deviant reactions and responses were found; mild, when comparable signs were present with, however, less intensity; and none, if no neurological devi-
sign provides limited prognostic information for the practicing clinician.

In a retrospective study, Harris\textsuperscript{25} statistically analyzed the predictive power of selected items from the Movement Assessment of Infants (MAI)\textsuperscript{26} in identifying CP in a sample of low birth-weight infants who were examined initially at 4 months' corrected age. The MAI is a 65-item neuromotor assessment tool developed by physical therapists to examine motor behaviors in four areas: muscle tone, primitive reflexes, automatic reactions, and volitional movement. Based on a "4-month-profile" developed by Chandler and colleagues,\textsuperscript{26} 48 of the 65 items of the MAI can be scored as either "risk" or "no-risk."

The 229 infants in this sample were followed until 3 to 8 years of age. A variety of standardized and nonstandardized tests were administered at the follow-up visits. Medical diagnoses of different types of CP were made for 36 of the children. Using chi-square tests, Harris analyzed the presence or absence of risk scores for each of the 48 risk items for the group of children with CP and a group who were deemed "normal," or nonhandicapped, at the final follow-up visit (n=118). Data for a third group of children with developmental delay were not analyzed at this time.\textsuperscript{25}

There were 32 MAI items that discriminated between the group of children with CP and the nonhandicapped children. In addition, the group of children with CP was subdivided into three diagnostic categories: spastic diplegia, spastic hemiplegia, and quadriplegia. Each diagnostic category contained 7 items that were significantly different for the children with spastic diplegia and spastic hemiplegia versus the nonhandicapped group. For the subgroup with quadriplegia, many of whom were moderately to severely involved, 35 items were significant predictors. Similarities between Harris's\textsuperscript{25} findings and those of the previous studies by Amiel-Tison et al.\textsuperscript{20} Ellenberg and Nelson,\textsuperscript{21} and Touwen and Hadders-Algra\textsuperscript{23} will be highlighted in an effort to examine commonalities across the four studies.

Although the MAI does not have a specific item labeled as "neck hyperextension," the item that most closely measures this behavior is a primitive reflex item—tonic labyrinthine reflex in the supine position. Using procedures similar to those described by Amiel-Tison and colleagues\textsuperscript{20} and Touwen and Hadders-Algra,\textsuperscript{23} this behavior is assessed through both visually observing the child's neck and shoulder girdle and passively moving the child's head, shoulders, and hips against gravity.\textsuperscript{26} A risk score is attained if there is only "occasional arching of the neck and/or some retraction at the shoulder girdle."

\textsuperscript{20,21} These criteria suggest a milder degree of neck hyperextension and shoulder retraction than was used to determine risk in the studies by Amiel-Tison and colleagues\textsuperscript{20} and Touwen and Hadders-Algra.\textsuperscript{23} This MAI item was significantly discriminative of later CP, both in the CP group as a whole and in the quadriplegic subgroup. Fifty-four percent of the children in the CP group and 90% of the children in the quadriplegic subgroup received a risk score for this item versus approximately 18% of the nonhandicapped group. Thus, all four studies reviewed suggest that this is an extremely important movement behavior to assess as an aid to the early diagnosis of CP (Table).

Another diagnostic predictor common to findings in the studies by Ellenberg and Nelson\textsuperscript{21} and Harris\textsuperscript{25} was the infant's ability to support weight on the forearms. This behavior is measured in part by several different MAI items: the infant's antigravity muscle tone when placed in the prone position, the tonic labyrinthine reflex in the prone position, and active weight bearing through the shoulders in the prone position. The first two behaviors were significantly different for the CP group as a whole. The volitional movement item—active weight bearing through the shoulders—was scored as a risk behavior for 34.3% of the children who developed CP versus 12.8% of the children who were labeled nonhandicapped at the final follow-up visit. A child's inability to support weight on the forearms at 4 months of age had a relative risk of 12 in Ellenberg and Nelson's study; 4.8% of low birth-weight infants and 2.1% of term birth-weight infants who showed this sign had CP at the age of

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<th>Neck Hyperextension/Shoulder Retraction</th>
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<th>Asymmetrical Movements</th>
<th>Tremulousness</th>
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<th>Inability to Keep Hands Open</th>
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\textsuperscript{2} + = predictive sign of later cerebral palsy, - = sign that failed to discriminate later cerebral palsy, NA = behavior not assessed.
7 years. The similarities in these findings across two studies conducted on 4-month-old infants suggest that the inability to assume and maintain a prone-on-elbows posture is an important diagnostic risk behavior (Table). One difference between the two studies, however, is that Harris assessed infants at 4 months' corrected age, whereas Ellenberg and Nelson used the infants' chronological age. Another difference between the two studies concerns their respective samples. Harris's sample consisted primarily of premature infants; Ellenberg and Nelson's much larger sample consisted of both term and preterm infants.

A common finding across these two studies was the lack of predictive significance of asymmetries (Table). Ellenberg and Nelson concluded:

Asymmetrical movements were not a statistically significant predictor of CP in general, nor of hemiparesis in particular, in either birthweight group or in the total.21,25

The MAI provides for assessment of asymmetry in each of the four sections of the tool. Harris concluded:

For the overall CP group, asymmetry was a predictive finding only in the section on muscle tone (p=0.021). For the subgroups, asymmetry of tone was predictive only for the quadriplegia group. In the sections on automatic movements and volitional movement, there were higher proportions of asymmetry risk scores among the group of children who were subsequently non-handicapped than for the CP group as a whole.25

These findings suggest that asymmetries, except perhaps in the area of muscle tone, are normal movement behaviors at 4 months of age and probably earlier. Whether asymmetrical movement behaviors are predictive of CP at 5 or 6 months of age or even later remains open to study.

The inability to sit with support was 15 times more common among infants who later developed CP than among infants with subsequent normal development in Ellenberg and Nelson's study. The most analogous MAI item is a volitional movement item that assesses the child's ability to maintain a stable head position in supported or independent sitting. A risk score is attained if the infant's head bobs, even if there is "some ability to hold head upright."26 Risk scores for this item were obtained by 33.3% of children in the CP group as a whole and by 60% of children in the quads subgroup versus 11.3% of the normally developing children, making this behavior a significant discriminator of later CP. Harris concluded:

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Common to both studies by Ellenberg and Nelson and Harris was the importance of abnormal muscle tone as a predictor of CP. Whereas the earlier study by Ellenberg and Nelson demonstrated that hypertonia was a more ominous sign than hypotonia, the data analysis by Harris did not differentiate these two types of tone, despite the fact that the MAI does allow for scoring of both hypotonia and hypertonia. Whereas Ellenberg and Nelson's study showed that abnormal truncal tone had a greater relative risk than abnormal tone of the extremities, Harris's study using the MAI demonstrated that risk scores for both behaviors occurred in a significantly higher proportion of children in the CP group than in the nonhandicapped group (42.9% versus 16.1% for trunk tone; 60% versus 26.5% for extremity tone).

Another somewhat contradictory finding between Ellenberg and Nelson's study and Harris's study was related to the presence of tremulousness. Whereas tremulousness in the low birth-weight children was associated with a sixfold increase in the rate of CP by Ellenberg and Nelson, the MAI item measuring tremulousness did not significantly predict later handicap for the CP group as a whole or for any of the subgroups. Nonetheless, the proportion of children in the CP group who demonstrated a risk score on tremulousness was more than twice as great as the proportion of nonhandicapped children with a risk score in Harris's MAI study (17.1% versus 6.8%).

Neither Ellenberg and Nelson's study nor Harris's study demonstrated predictive significance of the positive support reflex among low birth-weight infants, except for the subgroup of children with quadriplegia in Harris's study.

Clinical Implications of Recent Research Findings

Although it is difficult to draw perfect comparisons among studies that used different assessment tools and different samples of infants assessed at somewhat different ages, it is nonetheless helpful to try to assess similarities and differences among these studies with the aim of identifying movement behaviors that could be the most predictive of CP in both clinical and research settings. Attempts should also be made to behaviorally define these movements for consistency in visual analysis rather than to infer their underlying cause. An example is the MAI item "tonic labyrinthine reflex in supine." The movement behaviors that are actually being measured are neck hyperextension and shoulder retraction. Whether these deviant behaviors are caused by abnormal primitive reflex patterns, abnormal muscle tone, or a combination of these factors is of less concern to the physical therapy diagnostician than is a reliable means of assessing their presence or absence or their relative strength or frequency. The fact that the incidence of these behaviors ranged from 42% to 90% of the infants who later developed CP or other neurological handicap across the three prognostic studies suggests that assessment of these behaviors is extremely important.
maintain a stable head position in supported or independent sitting.\textsuperscript{21,25} Similar prognostic “milestone” behaviors need to be developed for other age levels based on prospective longitudinal studies. The lack of predictive significance of asymmetrical movements at 4 months of age is another important commonality across the studies by Ellenberg and Nelson\textsuperscript{21} and Harris.\textsuperscript{25} Pediatric physical therapists traditionally have placed great import on the presence of asymmetrical movements; although such movements may be important in the older infant with early CP, they are probably of little prognostic significance in infants up to at least 4 months of age unless they are extreme and obviously interfere with normal movement patterns.

Muscle tone abnormalities also appear to be important predictors of CP in 4-month-old infants. It is probably more important to operationally define movement differences as seen in antigravity postures, for example, than to infer that these differences are due to underlying tone disorders. Of the six individual muscle tone items on the MAI, three are active tone items that involve a visual analysis of the infant’s ability to move against gravity in the prone, supine, and prone suspension positions.\textsuperscript{20} All three of these “tone” items were highly significant predictors of later CP. In contrast, of the three passive tone items—which involve handling and passive manipulation rather than visual analysis of movement patterns—only one (extensibility) was as significant a predictor. These findings support Milani-Compari\textsuperscript{37}’s clinical assertion that watching how the infant moves against gravity is of greater diagnostic value than trying to stimulate responses through passive manipulation or handling.

The ultimate goal of early diagnosis of CP is the provision of early therapeutic intervention, often in the form of developmentally based physical therapy or occupational therapy. Recent research\textsuperscript{28} examining the relative efficacy of early physical therapy intervention, in the form of neurodevelopmental treatment (NDT), as compared with a more global infant stimulation program, suggested that the latter approach effected more positive developmental motor outcomes than did the NDT approach. Criticism has been directed at this study because of apparent inequities between the two groups in terms of severity of neurological impairment and because of the researchers’ use of outcome measures that were not sensitive to the goals of NDT.\textsuperscript{29,30} Future efficacy research in CP should include outcome measures that are congruent with the aims of treatment. For example, Kluzik and colleagues\textsuperscript{5} studied the effects of NDT on qualitative aspects of reaching in children with spastic quadriplegia via quantitative kinematic analysis of the “smoothness” of the reach.

Earlier diagnosis of CP (ie, within the first postnatal year) will enhance our abilities to examine further the efficacy of early treatment. Although the study by Palmer and colleagues\textsuperscript{38} included infants with spastic diplegia, ranging in age initially from 12 to 19 months, no study has been published attempting to examine the effectiveness of early physical therapy intervention for infants with CP who are less than 1 year of age.

**Future Trends in Movement Analysis for the Early Diagnosis of Cerebral Palsy**

As we expand our role to become diagnosticians, we must rely increasingly on reliable and standardized techniques for assessing movement differences as an aid to diagnosis. Assessment tools such as the MAI have been shown to be both reliable and valid in the assessment of high-risk infants,\textsuperscript{31–33} but additional research is needed to increase the sensitivity and specificity of such tools in the early diagnosis of CP.

The traditional medical emphasis on the passive assessment of muscle tone and primitive reflexes must be replaced by a new focus on systematic analysis of movement differences through visual observation, videotapes, and kinematic recordings. The assessment of primitive reflexes has perhaps been overemphasized to the exclusion of more important and more functional movement behaviors such as early motor patterns required for feeding, visual tracking, eye-hand coordination, and parent-infant interaction. Research\textsuperscript{34,35} on the reliability and predictive validity of the MAI has shown that primitive reflexes, as a group, “are the least reliable and valid predictors of later motor handicap”\textsuperscript{33} (p 39).

Through movement analysis of videotapes of neurologically normal and high-risk infants, physical therapists could begin to operationally define movement differences between these two groups. Longitudinal follow-up of such infants could assist in determining which movement behaviors were most predictive of later neurological handicap. Attempts must be made to quantify the frequency and variety of movement patterns through standardized observational protocols. Exciting progress is being made in the area of kinematic analysis of infant movements by physical therapist researchers using digitized data from videotapes to examine organization of infant movements\textsuperscript{34,35} and possible differences in movement between preterm and full-term infants.\textsuperscript{36} Longitudinal follow-up of the developmental outcome of these infants would allow for evaluation of the prognostic significance of movement differences.

Another exciting avenue for future research is the diagnosis of movement differences in utero through the use of fetal ultrasound. Milani-Compari\textsuperscript{37} has proposed that perinatally acquired CP could perhaps be prevented or minimized by obstetrical modifications for infants identified in utero as having impaired movements. As physical therapists become increasingly involved in fetal analysis of movement differences,\textsuperscript{39} it is hoped that we can assist in prenatal diagnosis of CP.

As specialists in movement analysis, physical therapists must continue to conduct research that will aid in the diagnosis and treatment planning for
movement disorders such as CP. As Rose concluded in his description of the roles and functions of physical therapy diagnosis, “Excellence in practice, now and in the future, requires physical therapists to be skillful diagnosticians.” 5/0357

It is hoped that this review of recent research on diagnostic movement predictors of CP will assist physical therapists in their ability to identify children with CP and physical therapist researchers in developing hypotheses for prospective studies aimed at further defining and classifying this important movement disorder during early infancy.

References

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