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(EN) **Assessment of psychomotor development in infants at risk: a proposal for a standardized assessment protocol (IPDA)**

(SK) **Hodnotenie psychomotorického vývinu u rizikových dojčiat: návrh štandardizovaného hodnotiaceho protokolu (H-PMV)**

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SUMMARY/ABSTRACT

Starting point: Early identification of motor abnormalities in infancy is crucial for optimizing the timing of rehabilitation interventions and improving outcomes in children at risk of developing cerebral palsy (CP). Although several standardized tools are used in current clinical practice, no integrated protocol systematically links qualitative and quantitative parameters of psychomotor development.
Objectives: The aim of this study was to develop assessment protocol *Integrated Psychomotor Development Assessment (IPDA)*, designed to objectively evaluate psychomotor development in infants at risk for CP and other neurodevelopmental disorders.
Methods: IPDA was created for a multicenter randomized clinical trial comparing the effects of the Vojta method and its combination with the Stimulation Positioning on a Human (SPHu) concept. Its structure is based on principles of developmental neurokinesiology, pediatric neurology, and published evidence regarding predictive indicators of CP.
Results: IPDA protocol is designed as an integrated assessment framework encompassing multiple domains of psychomotor development, including gross motor function/spontaneous motor activity (GMFM-88), postural reactions, primitive reflexes, qualitative postural indicators, and developmental milestones. It allows for the calculation of a composite total score as the sum of the individual assessed domains.**Conclusions:** IPDA is proposed as a standardized assessment protocol that extends existing diagnostic approaches through the integration of qualitative and quantitative motor parameters. Its clinical applicability and psychometric properties warrant further evaluation in validation studies.

KEYWORDS
psychomotor development; cerebral palsy; early diagnosis; Vojta method; Stimulation Positioning on a Human (SPHu) concept; GMFM-88; neurokinesiology

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1 INTRODUCTION

Despite major advances in prenatal, perinatal, and neonatal care, cerebral palsy (CP) remains the most common cause of permanent motor disability in childhood, with a prevalence of 1.4–2.1 per 1,000 live births (McIntyre, 2022; Saranti, 2024; Smithers-Sheedy, 2024). This persistent burden highlights the need

for continuous reappraisal of therapeutic strategies aimed at optimizing motor function, functional abilities, independence, and quality of life in children with CP. In line with principles of evidence-based medicine, active, task-oriented, and motivation-enhancing interventions—planned according to individualized goals and the child's specific functional needs—are preferred. Key determinants of therapeutic effectiveness include personalization of the intervention's content, intensity, and frequency, together with active family involvement (Morgan, 2021; Novak, 2017, 2025; Noritz, 2022; Hornáček, 2021a; Faccioli, 2023).

Current rehabilitation practice underscores the importance of early identification of infants at increased risk for neurodevelopmental disorders and the initiation of targeted intervention even before a definitive diagnosis can be established (Morgan, 2021; Noritz, 2022). The timing of rehabilitation initiation represents one of the most significant modifiable prognostic factors in children at risk for, or already diagnosed with, cerebral palsy (CP). The "act before diagnosis" paradigm shifts the emphasis from passive monitoring to active intervention during the period of maximal neuroplasticity and is supported by current international recommendations (Morgan, 2021; Noritz, 2022; Novak, 2025).

Early screening is therefore essential for appropriately timing individualized rehabilitative care, which may contribute to optimizing psychomotor development and improving functional outcomes.

2 STARTING POINT, OBJECTIVE, TASKS

The aim of this study is to present and methodologically define a newly developed assessment protocol (IPDA) designed to objectively evaluate psychomotor development in infants during the first year of life. The protocol was developed for use in an ongoing multicenter randomized clinical trial comparing the effectiveness of the Vojta method and its combination with the Stimulation Positioning on a Human (SPHu) concept in infants at risk of motor developmental disorders. The SPHu concept represents a recent therapeutic approach based on proprioceptive facilitation achieved through positioning the infant in postures derived from principles of developmental kinesiology; however, current evidence on its effectiveness remains limited (Hornáček et al., 2021b).

2.1 THE IMPORTANCE OF EARLY DIAGNOSIS AND INTERVENTION

The first 12 months of life represent a critical neurodevelopmental period characterized by rapid maturation of postural control mechanisms, progressive integration of sensorimotor inputs, and the emergence of early predictive movement models within the central nervous system. This period is marked by a high degree of neuroplasticity, creating a unique therapeutic window during which the trajectories of motor, cognitive, and sensorimotor development can be effectively shaped.

Early rehabilitation has been shown to influence the reorganization of the motor cortex, subcortical circuits, and descending motor pathways, translating into improved functional outcomes and a reduced

risk of later complications (Morgan, 2021; Sanchez, 2024; Novak, 2025). In the youngest children at risk of, or already diagnosed with, cerebral palsy—particularly those under two years of age—clinical practice commonly employs therapeutic approaches grounded in neurophysiological principles. These interventions focus on facilitating head control, activating the supporting functions of the shoulder and pelvic girdles, stabilizing the trunk, promoting verticalization, and training fundamental gait patterns (Dewar, 2015; Kolář, 2020; Faccioli, 2023).

Targeted neuromotor stimulation and modulation of sensorimotor inputs during periods of heightened neuroplasticity have the potential to correct developmental deviations before maladaptive motor strategies become consolidated (Hadders-Algra, 2021; Razak, 2024). Early, goal-directed intervention is one of the key modifiable determinants of developmental trajectories in children at risk for, or already diagnosed with, cerebral palsy (CP). Interventions initiated within the first months of life provide the most effective support for neuroplasticity and the physiological maturation of motor functions. Systematic reviews and clinical guidelines consistently report that therapies initiated before six months of age yield the greatest benefits for both motor and cognitive development (Novak, 2017; Hadders-Algra et al., 2017; Damiano, 2021; Morgan, 2021; Noritz, 2022).

The effective implementation of early intervention requires standardized, reproducible, and quantifiable assessment of psychomotor development (PMD), enabling objective monitoring of developmental change and evaluation of therapeutic efficacy over time (Novak, 2025).

2.2 STANDARDIZED EARLY DIAGNOSIS OF CEREBRAL PALSY

Standardized assessment tools such as the General Movements Assessment (GMA), the Hammersmith Infant Neurological Examination (HINE), and brain magnetic resonance imaging (MRI) make a substantial contribution to the early diagnosis of cerebral palsy (CP). According to recent recommendations (Novak et al., 2025), the combined use of these three methods enables diagnosis—or identification of infants at high risk of CP—as early as 3 months of corrected age. MRI demonstrating motor pathway injury (sensitivity 86–89%), absent fidgety movements on GMA (sensitivity 98%), and low HINE scores (<57 at 3 months) together yield 98% sensitivity and 99% specificity. An integrated diagnostic model incorporating MRI, GMA, and HINE currently represents the most reliable and internationally recommended approach for the early identification of infants at high risk of CP (Razak, 2024; Novak, 2025).

In addition to standardized assessment tools, neurokinesiological examination plays a pivotal role in clinical practice. Contemporary neurodevelopmental literature demonstrates that the quality of spontaneous motor behavior, reflex activity, and postural reactivity represent complementary domains with substantial diagnostic value. The combined assessment of motor functions, primitive developmental reflexes, and postural reactions is repeatedly identified as a sensitive and predictive clinical marker of impaired central motor regulation in infancy (Zafeiriou, 2004; McQueen, 2025; Fears, 2025).

Postural reactivity is among the most important indicators of central nervous system integrity, as postural responses are mediated by complex polysynaptic circuits integrating the brainstem, vestibular nuclei, cerebellum, basal ganglia, and corticospinal projections. Abnormal postural responses constitute a significant prognostic marker of elevated risk for subsequent motor dysfunction, including CP.

2.3 SPECIALIZED NEUROKINESIOLOGICAL CONCEPTS IN EARLY DEVELOPMENT

This clinical framework provides the basis for implementing specialized **neurokinesiological approaches** that allow detailed assessment of qualitative aspects of developmental postural and locomotor mechanisms. The most prominent and internationally established of these is Vojta's reflex locomotion method, which constitutes a comprehensive system for analyzing developmental postures and postural reactions with high diagnostic accuracy in early infancy. Grounded in the Czechoslovak tradition of developmental kinesiology, the Vojta method enables not only reflex activation through defined stimulation zones but also a detailed evaluation of the maturation of central postural regulation and the emergence of early locomotor patterns. Key assessment parameters include the quality of supporting functions with physiological proximodistal organization, the degree of segmental limb differentiation, the coordination of axial trunk rotation within the context of appropriate postural stabilization, and ventrodorsal muscle coactivation responses under load.

This concept represents a clinically relevant diagnostic tool for the early identification of motor developmental disorders in infants at increased risk of cerebral palsy, particularly among preterm newborns (Sánchez-González et al., 2024; Trafalska & Paprocka-Borowicz, 2025). Neurokinesiological assessment plays a pivotal role in the early detection of central coordination disorder, cerebral palsy (CP), and developmental coordination disorder (DCD), while also guiding the optimal timing of targeted rehabilitation interventions. Prospective longitudinal studies (Zounková & Hladíková, 2012; De Roubaix et al., 2025) consistently demonstrate that even subtle deviations from physiological motor ontogenesis during early infancy may constitute early phenotypic manifestations of neurodevelopmental disorders. These findings underscore the importance of detailed evaluation of postural–motor function quality within the first months of life.

Current evidence on the neurophysiological mechanisms of postural control indicates that the quality of developmental motor patterns—particularly the degree of differentiation of postural support function, the level of axial stability, and the appropriateness of postural responses under load—constitutes a more sensitive indicator of central nervous system maturation than the mere presence of persistent or pathological primitive reflexes (Zafeiriou, 2004). Longitudinal analyses (Dijkstra et al., 2020) further confirm that deviations in postural reactivity possess greater predictive value than isolated abnormalities of muscle tone or reflex activity. When integrated with findings from GMA, HINE, and MRI, these parameters sub-

stantially enhance the accuracy of early identification of infants at risk for neurodevelopmental disorders (Zafeiriou, 2004; Novak, 2025).

Qualitative aspects of motor behavior—specifically the assessment of the fluidity, variability, and complexity of the movement repertoire—represent a more powerful prognostic marker in early development than the sheer quantity of motor activity (Razak, 2024; Novak, 2025). In particular, the absence or abnormality of fidgety movements between 3 and 5 months of corrected age ranks among the strongest predictors of later motor and cognitive difficulties (Kwong, 2018; Lönnberg, 2025).

The neurophysiological concept of *internal models* refers to predictive sensorimotor schemas used by the central nervous system to plan, coordinate, and control movement. Deviations in early motor behavior may interfere with the maturation of these models, leading to motor planning impairments, disrupted sensorimotor integration, and the emergence of maladaptive compensatory strategies (Khalki, 2024). Experimental and clinical studies (Delcour et al., 2018; Martel et al., 2022) demonstrate that disrupted sensorimotor learning during critical periods of heightened neuroplasticity affects body schema organization, anticipatory postural adjustments, and the overall efficiency of motor control.

Early identification of qualitative deviations in infant motor behavior is therefore essential not only for distinguishing benign physiological variation, but also as a sensitive marker of early phenotypic manifestations of neurodevelopmental disorders (Bowler, 2024). According to Zounková and Hladíková (2012), qualitative postural abnormalities detectable as early as the fifth week of life—particularly hip hyperabduction, pelvic anteversion, trunk asymmetry, and shoulder protraction—constitute significant risk indicators of impaired central regulation of postural functions. These findings are associated with a reduced developmental quotient and with the persistence of postural abnormalities later in development.

The Slovak Standard Diagnostic and Therapeutic Procedures for the Rehabilitation of Cerebral Palsy (Klobucká, Chamutyová, 2020) recommends that newborns at risk undergo their first assessment by a specialist in Physical and Rehabilitation Medicine within the first six weeks of life, followed by regular interval-based monitoring of psychomotor development.

2.4 STANDARD NEUROKINESIOLOGICAL ASSESSMENT OF THE INFANT IN A PHYSICAL AND REHABILITATION MEDICINE CLINICAL SETTING

The neurokinesiological assessment of an infant constitutes a comprehensive evaluation of the functional organization of the central nervous system, aimed at the early detection of sensorimotor integration disorders. The examination begins with a detailed neurodevelopmental history that includes prenatal and perinatal risk factors, the course of postnatal adaptation, attainment of developmental milestones, and the infant's current neurobehavioral status. These data provide the essential context for interpreting subsequent clinical findings (Figure 1).

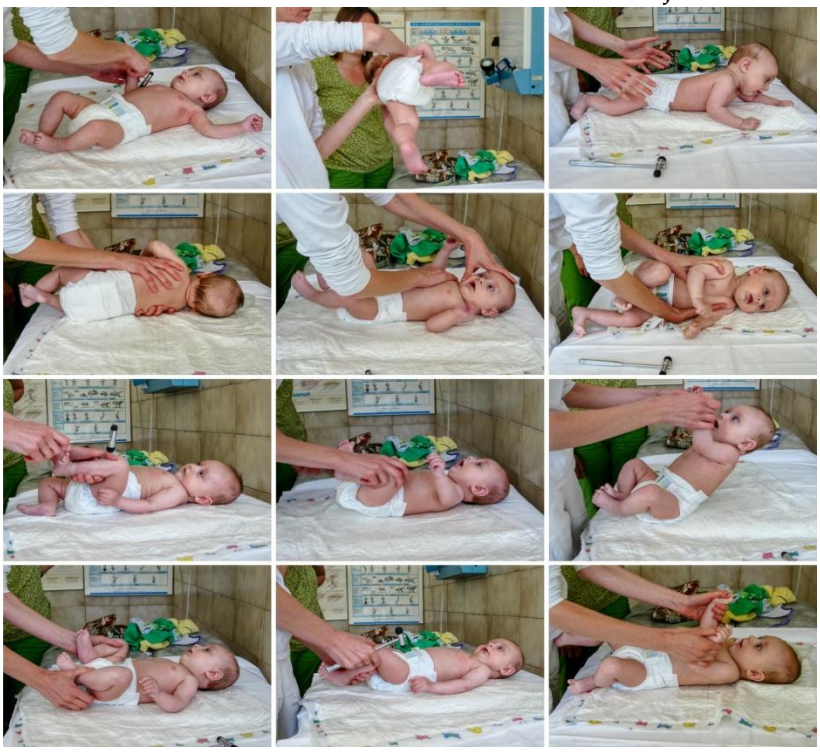

Figure 1 – Neurokinesiological examination of an infant (source: author's archive)

Assessment of spontaneous motor behavior is a key component of the examination, as it represents the most sensitive indicator of the functional integrity of suprasegmental sensorimotor control systems. The evaluation focuses on the fluency, variability, and complexity of the movement repertoire, the quality of rotational patterns, lateral organization, and the degree of postural engagement of the trunk. Motor characteristics such as a poor repertoire, reduced variability, cramped-synchronized movements, or persistent asymmetry are described in the literature (Prechtl, Einspieler, Hadders-Algra) as reliable markers of central dysfunction that may precede the clinical manifestation of motor impairment.

Postural reactions provide critical information on the maturity of automatic postural control and the functional involvement of brainstem, cerebellar, and corticospinal structures. They are elicited through standardized provocation maneuvers, and the assessment focuses on the quality of both global postural responses and segmental component reactions, consistent with the Central European neurokinesiological tradition shaped by the work of Vojta, Janda, Lewit, and Kolář. Deviations in postural reactions may indicate impaired anticipatory postural control or insufficient segmental differentiation.

Developmental (primitive) reflexes are assessed with respect to their presence, symmetry, intensity, and the physiological timing of their attenuation relative to postconceptional age. Prolonged persistence or maladaptive expression of these reflexes indicates impaired maturation of the brainstem and descending inhibitory pathways.

The assessment of muscle tone complements the evaluation of the functional organization of the central nervous system. The examination focuses on the axial and peripheral distribution of tone, reactivity

under load, the quality of supporting functions, and the tonic alignment of the trunk. Deviations in muscle tone frequently reflect dysfunction of descending pathways and may give rise to secondary compensatory strategies that alter the physiological trajectory of developmental motor patterns.

An integrated synthesis of these parameters enables the clinician to establish a syndromological profile of the infant, providing a robust basis for early identification of the risk of cerebral palsy and other neurodevelopmental disorders, for determining the severity of the clinical findings, and for optimally timing targeted intervention during the period of greatest neuroplastic potential.

3 GROUP AND METHODS

This methodological study presents the developmentand structure of the IPDA protocol (Integrated Psychomotor Development Assessment), designed for the purposes of multicenter study ***"Follow-up of Vojta Therapy and Stimulation Positioning on a Human in Infants at High Risk of Cerebral Palsy"*** (2024–2026), in which the protocol was applied in clinical practice.

. The assessment is conducted by a specialist in physical and rehabilitation medicine (Figure 1).

3.1 SELECTION OF ASSESSED PARAMETERS

To objectify and quantify psychomotor development in infants from five months of corrected age onward, we developed assessment protocol—IPDA. The structure of the protocol and the selection of assessment domains are grounded in current knowledge from developmental neurophysiology, pediatric neurology, and developmental kinesiology, as well as in published evidence on predictive markers of risk for cerebral palsy and other neurodevelopmental disorders. The included items encompass complementary domains of motor development—from reflex motor activity, through postural mechanisms and segmental stability, to goal-directed motor skills— thereby enabling multidimensional and longitudinal assessment of psychomotor development.

3.2 STRUCTURE OF THE IPDA PROTOCOL

Assessment of spontaneous motor behavior using the Gross Motor Function Measure (GMFM) constitutes an internationally validated and widely utilized quantitative method for evaluating gross motor function in children with motor developmental disorders, particularly cerebral palsy (Russell, 2000, 2002, 2013). Both GMFM-88 and GMFM-66 demonstrate high reliability, validity, and sensitivity to change across a broad age spectrum, including infants younger than 24 months (Koziol, 2025).

In contrast to developmental scales designed primarily for early motor screening (e.g., the Alberta Infant Motor Scale (AIMS), Test of Infant Motor Performance (TIMP), the GMFM provides normalized scores applicable well into later childhood, thereby enabling longitudinal monitoring of motor developmental trajectories across an extended age range. Dimensions A–C capture key stages of early motor development—supine and prone postures, sitting, and the initiation of antigravity movements—and are par-

ticularly suitable for evaluating infants and young children with neurodevelopmental deviations, where high sensitivity to subtle changes in motor ability is required (Rosenbaum, 2002). Although Koziol et al. (2025) demonstrated strong validity and responsiveness of the GMFM-66-IS in infants under 24 months, the GMFM-88 was employed in our study because it encompasses a broader item set and enables more detailed characterization of early motor patterns. When combined with the IPDA protocol, the GMFM-88 provides a comprehensive evaluation of both quantitative and qualitative aspects of motor function in early childhood.

Postural reactions represent a clinically significant neurophysiological marker of the maturation of postural control mechanisms, which are modulated by brainstem, cerebellar, and corticospinal systems. During the first year of life, PRs constitute one of the most sensitive indicators of the integrity of central motor regulation and serve as an important predictor of the quality of subsequent motor development. Within the IPDA protocol, PRs are quantified as a fraction (number of physiological reactions / number of reactions tested), allowing differentiation between physiological, partially impaired, and pathological responses. The scoring system permits both binary and partial grading, thereby supporting reliable longitudinal tracking of developmental change and ensuring comparability of results across assessments. Their clinical relevance has been repeatedly confirmed in the neurodevelopmental literature (e.g., Zafeiriou 2004; Einspieler & Prechtl, 2005), which emphasizes their diagnostic value in the early identification of central motor coordination disorders.

Reflex symptomatology (Developmental (primitive) reflexes) encompasses a set of selected primitive reflexes with the highest predictive value for pathological neurodevelopment, particularly for the early identification of infants at risk of developing cerebral palsy. The assessment routinely includes reflexes representing brainstem, spinal, and cortico-subcortical levels of the nervous system (asymmetric tonic neck reflex, Moro reflex, Babkin reflex, tonic grasp reflexes of the upper and lower limbs, Galant reflex, Babinski reflex, Rossolimo reflex, suprapubic extensor reflex, and the heel reflex). The evaluation focuses on the persistence, asymmetry, and intensity of reflex responses, which are clinically meaningful indicators of the integrity of central motor regulation. The predictive value of individual reflexes—both assessed in isolation and as part of a combined profile—and their contribution to early diagnosis and differential diagnosis of cerebral palsy have been documented in numerous clinical and longitudinal studies. Combined assessment of primitive reflexes and postural reactions is regarded as one of the most reliable early screening approaches for evaluating central nervous system integrity, particularly when more than five pathological responses are identified (Zafeiriou, 2004).

IPDA protocol is designed as a unified assessment framework without differentiation between mandatory and conditional items. All parameters are recorded in each assessed child, with their interpretation consistently contextualized to age and level of developmental maturity. Certain motor manifestations and

reflex responses are physiologically interpretable only at specific stages of central nervous system development, which must be taken into account when interpreting the results.

3.3 DEGREE OF CENTRAL COORDINATION DISORDER (CCD 1–4)

Central Coordination Disorder (CCD) and Central Tonic Disorder (CTD) are functional, non-nosological categories derived from the Central European neurodevelopmental framework established by Vojta. Their primary purpose is the early identification of infants at risk for motor developmental disorders during a period in which an etiologically or nosologically precise diagnosis cannot yet be determined. CCD describes deviations in postural and movement patterns evaluated through standardized assessment of postural reactions and reflex motor behavior. CTD denotes centrally mediated abnormalities of muscle tone (hypotonia or hypertonia) without a specific association with a defined nosological entity.

The severity of CCD is determined based on the number and quality of pathological postural responses, allowing objective stratification of central motor deficits and supporting comparability of findings across assessments. Although these categories are not equivalent to international diagnostic systems (e.g., ICD), they provide a clinically useful framework for identifying functional abnormalities before the manifestation of definitive pathology. In current clinical practice, they hold a well-established role in the early screening of infants at risk for motor disorders and support decision-making regarding the need for follow-up or early intervention (Klobucká, 2018).

3.4 QUALITATIVE PARAMETERS OF MOTOR ORGANIZATION

The qualitative indicators of motor organization evaluated include trunk and limb asymmetry, diastasis of the rectus abdominis muscle, trunk hyperextension, and hip hyperabduction. These clinical signs reflect impaired segmental stabilization, insufficient activation of the deep stabilization system, and the presence of abnormal global movement strategies during early motor development. These parameters are routinely employed in the diagnostic assessment of CCD and in the evaluation of functional developmental deviations in infants, where they contribute to objectifying the quality of motor performance and informing decisions regarding the need for intervention.

3.5 LOCOMOTOR STAGES

Locomotor stages encompass the evaluation of the attainment of physiological developmental milestones, including rolling, crawling, creeping, independent sitting, standing, and walking. They represent an important indicator of the sequence of motor development and of the child's ability to integrate motor, postural, and sensory subsystems during central nervous system maturation. In clinical practice, they are used as a complementary parameter for evaluating the quality of motor performance, and in randomized controlled trials focused on developmental interventions, they serve as a secondary outcome measure.

3.6 DEVELOPMENTAL QUOTIENT (DQ = DEVELOPMENTAL AGE / CHRONOLOGICAL AGE)

The developmental quotient represents a summary index reflecting the level of motor or overall developmental profile relative to the child's chronological age. It is calculated as the ratio of the current developmental (motor) age—based on gross motor domains such as upright postural control and locomotion—to chronological age (Kolář, 2005) It enables comparison of psychomotor development across different age groups and supports longitudinal monitoring of developmental trajectories. In interventional studies, it is used to identify deviations from the expected rate of development and to analyze changes at both individual and group levels (Table 1). The DQ is intended as a comparative indicator rather than a standalone diagnostic parameter, and its interpretation should always be considered within the context of a comprehensive clinical assessment.

Table 1: Psychomotor Development Assessment: Components and Scoring Summary

Domain	Item	Definition / Scoring
POSTURAL REACTIONS	Postural Reactions	Recorded as a fraction: number of physiological postural reactions / total number of postural reactions observed.
	Parachute Reaction (+/–)	From6 months of age: present = 1 point, absent = 0 points.
CENTRAL COORDINATION DISORDER (CCD)	CCD Severity Level (1–4)	Scoring of central coordination disorder: CCD 1 = 3 points, CCD 2 = 2 points, CCD 3 = 1 point, CCD 4 = 0 points.
DEVELOPMENTAL REFLEXES	ATNR (+/–) (Asymmetrical Tonic Neck Reflex)	At 6 months: 1 point if absent (–).
	Moro Reflex (+/–)	1 point if absent (–).
	Tonic Upper-Limb Grasp Reflex (+/–)	1 point if absent (–).
	Tonic Lower-Limb Grasp Reflex (+/–)	1 point if present (+).
	Galant Reflex (+/–)	1 point if absent (–).
	Babinski Sign (+/–)	At 6 months: + = 1 point. At 9 months: + = 1 point. At 12 months: – = 1 point. After 12 months: + = 0 points.
	Rossolimo Reflex (+/–)	1 point if absent (–).
	Suprapubic Reflex (+/–)	1 point if absent (–).
	Crossed Extension Reflex (+/–)	1 point if absent (–).
	Heel Reflex (+/–)	1 point if absent (–).
	Babkin Reflex (+/–)	1 point if absent (–).
	Acusticofacial Reflex – RAF (+/–)	1 point if present (+).
	Opticofacial Reflex – ROF (+/–)	1 point if present (+).
POSTURAL ASYMMETRY	Asymmetry (0–2)	Evaluated in: head posture, trunk posture, spontaneous limb movements, grasp patterns, including early lateralized hand preference. 0 = consistently present; 1 = intermittently present; 2 = absent.
RECTUS ABDOMINIS DIASTASIS	Diastasis (0–2)	0 = present in epigastric, mesogastric and hypogastric regions; 1 = present in epigastric and mesogastric regions; 2 = absent.
TRUNK POSTURE	Trunk Hyperextension (0–2)	0 = consistently present; 1 = intermittently present; 2 = absent.
HIP POSITION	Hip Hyperabduction (0–1)	0 = present; 1 = absent.
DEVELOPMENTAL LEVEL	Developmental/Retardation Quotient (DQ)	Calculated as developmental age / chronological age.

The total IPDA score is calculated as the unweighted sum of individual item scores, with higher scores indicating more favorable functional outcomes. The protocol also enables domain-specific profiling of psychomotor development, thereby supporting a more comprehensive interpretation of the child's developmental profile.

In light of the methodological design of the study, clinical threshold values for risk stratification have not yet been defined. Psychometric validation of the protocol—including the assessment of validity, reliability, inter-rater and intra-rater agreement, diagnostic accuracy, and the establishment of clinical thresholds—is currently underway in a multicenter validation study.

Additional Recorded Variables (According to the Study Protocol)

- Patient name
- Gestational age at birth
- Age at study enrollment (corrected)
- Age at final assessment
- Birth weight
- Apgar score
- Sex
- Cranial ultrasonography (normal / abnormal)
- Primary diagnosis (e.g., central coordination disorder, hypoxic–ischemic encephalopathy, intrauterine growth restriction)
- Type and frequency of intervention (Vojta vs. SPHu)
- Number of therapy sessions
- Presence of epilepsy or other neurological symptoms
- Anthropometric data
- Parental cooperation
- Photo and video documentation (with informed consent)

4 RESULTS

IPDA was developed as a standardized assessment framework with a clearly defined structure and clinical rationale.

The protocol was implemented in an ongoing clinical study in infants aged over 5 months (corrected age) at risk of neurodevelopmental disorders.

The IPDA integrates principles of developmental kinesiology with standard components of the neurological examination, analysis of spontaneous motor behavior, and quantifiable functional measures (GMFM-88). It enables systematic and longitudinal assessment of postural reactivity, reflex symptomatology, segmental stabilization, and developmental motor stages. In addition, clinically relevant qualitative parameters—such as trunk asymmetry, hip hyperabduction, trunk hyperextension, and diastasis of the rectus abdominis—are incorporated to complement and enrich the information obtained from standardized tests.

IPDA is conceived as a complementary instrument, not intended to replace existing standardized scales, but rather to augment them through a detailed clinical assessment of the quality of motor and pos-

tural functions. In this way, it provides a systematic framework for reliable clinical evaluation as well as for research-oriented decision-making in the field of early neurorehabilitation.

Quantification of postural and reflex responses may contribute to longitudinal monitoring of developmental trajectories. Integration of quantitative indicators of functional performance with qualitative assessment of developmental patterns may support a comprehensive evaluation of motor development in the context of early diagnosis.

Data on the sensitivity, reliability, and clinical utility of the IPDA protocol are currently being investigated in an ongoing multicenter study and will be presented in separate publications.

5 DISCUSSION

Early identification of deviations from typical psychomotor development is one of the key determinants of prognosis in children at risk for cerebral palsy (CP). Targeted interventions delivered during periods of peak neuroplasticity significantly influence not only motor development but also cognitive and psychosocial developmental domains (Morgan, 2021; Noritz, 2022). In addition to early timing, a second critical prerequisite for effective intervention is the standardization of diagnostic assessment. Systematic reviews (Novak et al., 2025; Razak, 2024) consistently demonstrate that the absence of unified diagnostic protocols and the substantial variability in assessment approaches markedly limit the comparability of available data and contribute to delays in establishing a definitive diagnosis. Burgess et al. (2025) emphasize that the use of standardized assessment tools is essential for ensuring reliable clinical decision-making in the early diagnosis of developmental disorders. Standardized tools allow for more accurate stratification of neurodevelopmental risk, including the risk of developing cerebral palsy, support the optimization of intervention timing, and provide objective data for monitoring developmental trajectories and therapeutic response in accordance with evidence-based practice principles.

The proposed IPDA protocol integrates internationally validated instruments (particularly GMFM-88) with clinically relevant parameters derived from the Central European neurokinesiological tradition that are not independently standardized. The included parameters cover key aspects of motor ontogeny—from reflex responses to integrated functional patterns—enabling a comprehensive evaluation of the maturation of central motor regulation. Integration of quantitative and qualitative parameters offers a more differentiated perspective on motor organization and is conceptually aligned with the multidimensional approach of established international assessment tools (GMA, HINE, GMFM, TIMP), supporting its use in both clinical and research protocols. The protocol structure enables longitudinal monitoring of developmental trajectories in early infancy. This approach is consistent with current consensus recommendations on multidimensional screening, which emphasize the parallel assessment of reflex, postural, and spontaneous motor function in identifying neurodevelopmental risk. Although methodologically limited, the proposed

concept reflects routine clinical practice, in which qualitative assessment of postural and reflex organization plays a key role. Validation of this integrative approach and its individual components is currently underway.

Preliminary results indicate that the proposed IPDA protocol is capable of detecting subtle motor deviations prior to the emergence of fixed pathology, which is consistent with the current paradigm of early identification in at-risk infants. The integration of quantitative measures of functional performance with qualitative assessment of developmental movement patterns, reflexive activity, and postural motor behavior enhances screening sensitivity and enables standardized longitudinal monitoring.

The clinical relevance of this integrated approach is exemplified by item 3 in Dimension A of the GMFM, a key early-infancy marker of postural control. This item evaluates active head anteflexion in the supine position. Although defined within the GMFM as a positively scored performance, its spontaneous occurrence in very young infants—particularly when accompanied by lower-limb extension, plantar flexion, or pronounced activity of the rectus abdominis muscle (including diastasis)—may represent a compensatory motor pattern rather than a manifestation of physiologically maturing ventrodorsal coactivation. Functionally, this presentation resembles the symmetrical tonic neck reflex (STNR) and may reflect immaturity of axial stability mechanisms and central postural regulation.

Research evidence highlights the need for cautious interpretation of this motor behavior as a clinical "positive milestone." Van Haastert et al. (2012) demonstrated that active head anteflexion in the supine position, when accompanied by stereotyped lower-limb extension patterns, was associated with lower cognitive scores at two years of age—particularly in term-born boys—and that this association remained significant even after excluding children diagnosed with cerebral palsy. These findings, however, are not universal. A population-based study by van Iersel and Hadders-Algra (2021) showed that the mere presence of active head lifting from supine (AHLS) is not a negative prognostic marker. AHLS became potentially concerning only when it co-occurred with stereotyped lower-limb movements—such as extension, adduction, or plantar flexion—which correlated with poorer performance on standardized neurological and motor assessments (Infant Motor Profile; Screening Infant Neurological Developmental Assessment, SINDA).

From a clinical standpoint, it is therefore essential to interpret head anteflexion within the broader context of global movement-pattern quality—including axial postural control, symmetry, synergies, and postural responses to changes in position or stability—rather than viewing it in isolation as a stand-alone positive performance. When interpreting GMFM scores, it is advisable to supplement the assessment with documentation of observed compensatory strategies, as this allows clinicians to distinguish physiological variability from early manifestations of potentially impaired central postural regulation.

A limitation of the proposed IPDA protocol is that gross motor function can be quantified using the GMFM only from approximately five months of corrected age. In younger infants, GMFM scoring is not

interpretable; a low score reflects physiological immaturity of the motor system rather than a pathological deviation. Therefore, during the period before five months of age, other validated instruments—particularly the GMA, HINE, and TIMP—are more appropriate for the early identification of developmental deviations.

The results of our ongoing study will be disseminated continuously through scientific publications, conference presentations, and professional seminars, with the aim of promoting broader implementation of early diagnostic and intervention strategies in clinical practice, as well as in undergraduate and postgraduate education of healthcare professionals.

6 CONCLUSIONS

The IPDA protocol is proposed as a structured assessment approach for the evaluation of psychomotor development in infants at risk of neurodevelopmental disorders. It has the potential to contribute to greater standardization of diagnostic procedures, improved comparability of clinical data, and systematic longitudinal monitoring of psychomotor development, including its evaluation in the context of therapeutic interventions in accordance with the principles of evidence-based medicine. The IPDA is conceived as a complement to existing standardized tools, extending assessment by incorporating a detailed qualitative analysis of movement patterns and thereby supporting informed clinical decision-making. Integration of multiple domains enables a more comprehensive clinical evaluation; however, the validity, reliability, and clinical utility of the protocol require further evaluation.

7 ZUSAMMENFASSUNG

Hintergrund: Die frühzeitige Identifikation motorischer Auffälligkeiten im Säuglingsalter ist entscheidend für die Optimierung des Zeitpunkts rehabilitativer Interventionen sowie für die Verbesserung der Outcomes bei Kindern mit erhöhtem Risiko für die Entwicklung einer Zerebralparese (CP). Obwohl in der klinischen Praxis mehrere standardisierte Instrumente eingesetzt werden, fehlt bislang ein integriertes Protokoll, das qualitative und quantitative Parameter der psychomotorischen Entwicklung systematisch miteinander verknüpft.
Zielsetzung: Ziel der vorliegenden Studie war die Entwicklung des Bewertungsprotokolls *Integrated Psychomotor Development Assessment* (IPDA) zur objektiven Beurteilung der psychomotorischen Entwicklung bei Säuglingen mit Risiko für CP und andere neuroentwicklungsbedingte Störungen.
Methoden: Das IPDA wurde im Rahmen einer multizentrischen randomisierten klinischen Studie entwickelt, die die Effekte der Vojta-Methode sowie deren Kombination mit dem Konzept *Stimulation Positioning on a Human* (SPHu) untersucht. Die Struktur des Protokolls basiert auf Prinzipien der Entwicklungsneurokinesiologie, der pädiatrischen Neurologie sowie auf publizierter Evidenz zu prädiktiven Indikatoren der CP.
Ergebnisse: Das IPDA-Protokoll stellt ein integriertes Bewertungsinstrument dar, das mehrere Domänen der psychomotorischen Entwicklung umfasst, darunter grobmotorische Funktionen und spontane motorische Aktivität, bewertet mittels GMFM-88, posturale Reaktionen, primitive Reflexe, qualitative posturale Indikatoren sowie entwicklungsbezogene Meilensteine. Das Protokoll ermöglicht zudem die Berechnung eines zusammengesetzten Gesamtscores, der aus den einzelnen bewerteten Domänen abgeleitet wird.
Schlussfolgerungen: Das IPDA wird als standardisiertes Bewertungsprotokoll vorgeschlagen, das bestehende diagnostische Ansätze durch die Integration qualitativer und quantitativer motorischer Parameter erweitert. Die klinische Anwendbarkeit sowie die psychometrischen Eigenschaften des Protokolls bedürfen weiterer Überprüfung im Rahmen zukünftiger Validierungsstudien.

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