Use of the Hammersmith Infant Neurological Examination to identify infants with high likelihood of Cerebral Palsy and other Neurodevelopmental delays and/or Disability: an update of the evidence

Carly Luke[1,2] Rachel Thomas[2] and Roslyn N Boyd[1]

1 Queensland Cerebral Palsy and Rehabilitation Research Centre, The University of Queensland,;
2 Queensland Paediatric Rehabilitation Service, Queensland Children's Hospital, Brisbane;

Cerebral Palsy ALLIANCE RESEARCH FOUNDATION

Australasian Cerebral Palsy Clinical Trials Network AusCP-CTN Centre for Research Excellence

ADVANCE QUEENSLAND

Australian Government National Health and Medical Research Council

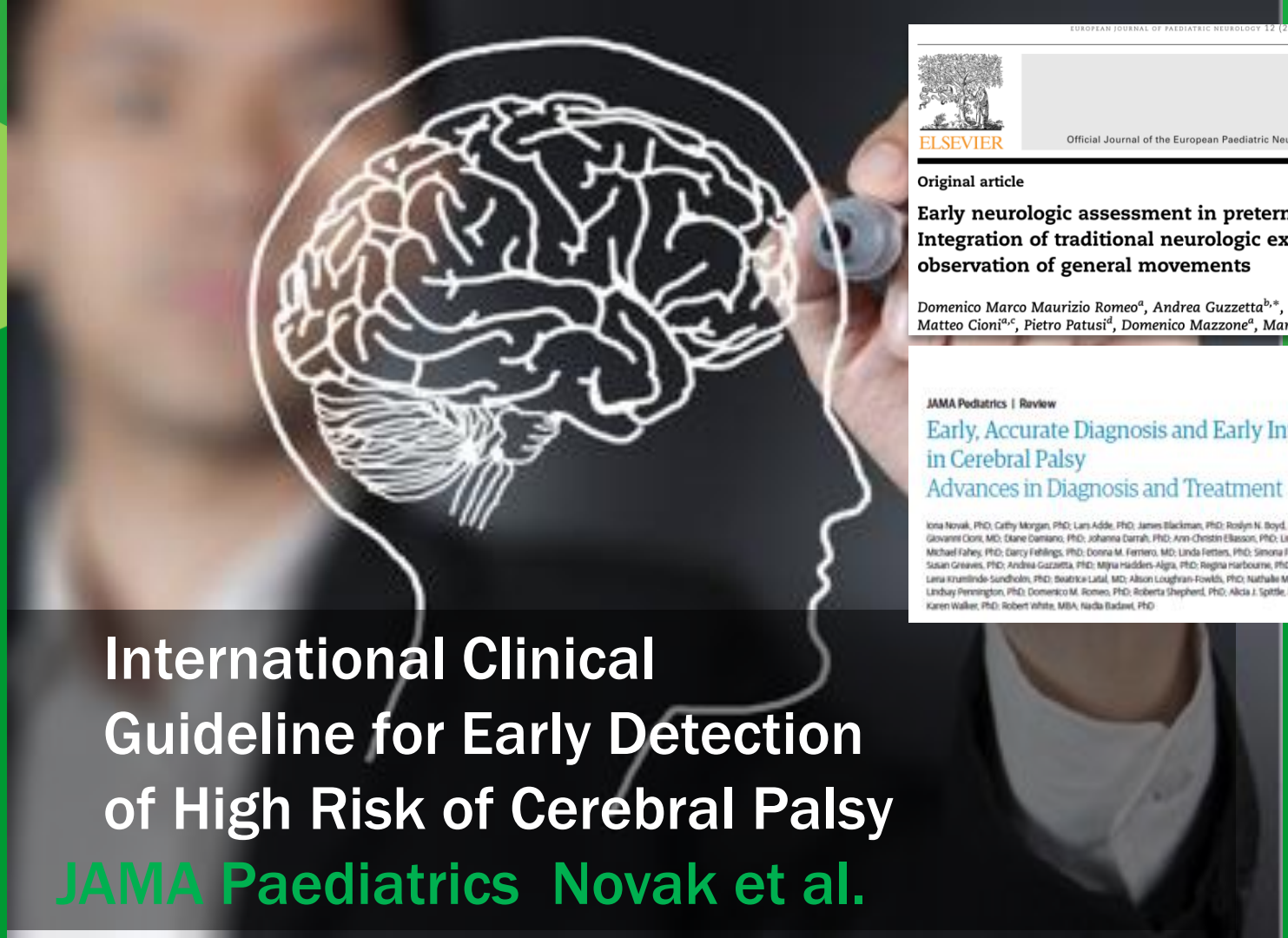
The University Of Queensland AUSTRALIA

Children's Health Queensland Hospital and Health Service

Structure of workshop

- QLD and International implementation (>800 clinicians)
- Implementation in a statewide early diagnosis clinic
- Update on the current evidence
- New directions and clinical utility of the HINE
- Interactive case studies
- Panel discussion

Let’s get to know each other!



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ELSEVIER

Official Journal of the European Paediatric Neurology Society

Original article

Early neurologic assessment in preterm-infants: Integration of traditional neurologic examination and observation of general movements

Domenico Marco Maurizio Romeo[a], Andrea Guzzetta[b,], Mariacristina Scoto[a], Matteo Cioni[a,c], Pietro Patusi[d], Domenico Mazzone[a], Mario Giuseppe Romeo[e]*

Clinical Review & Education

JAMA Pediatrics | Review

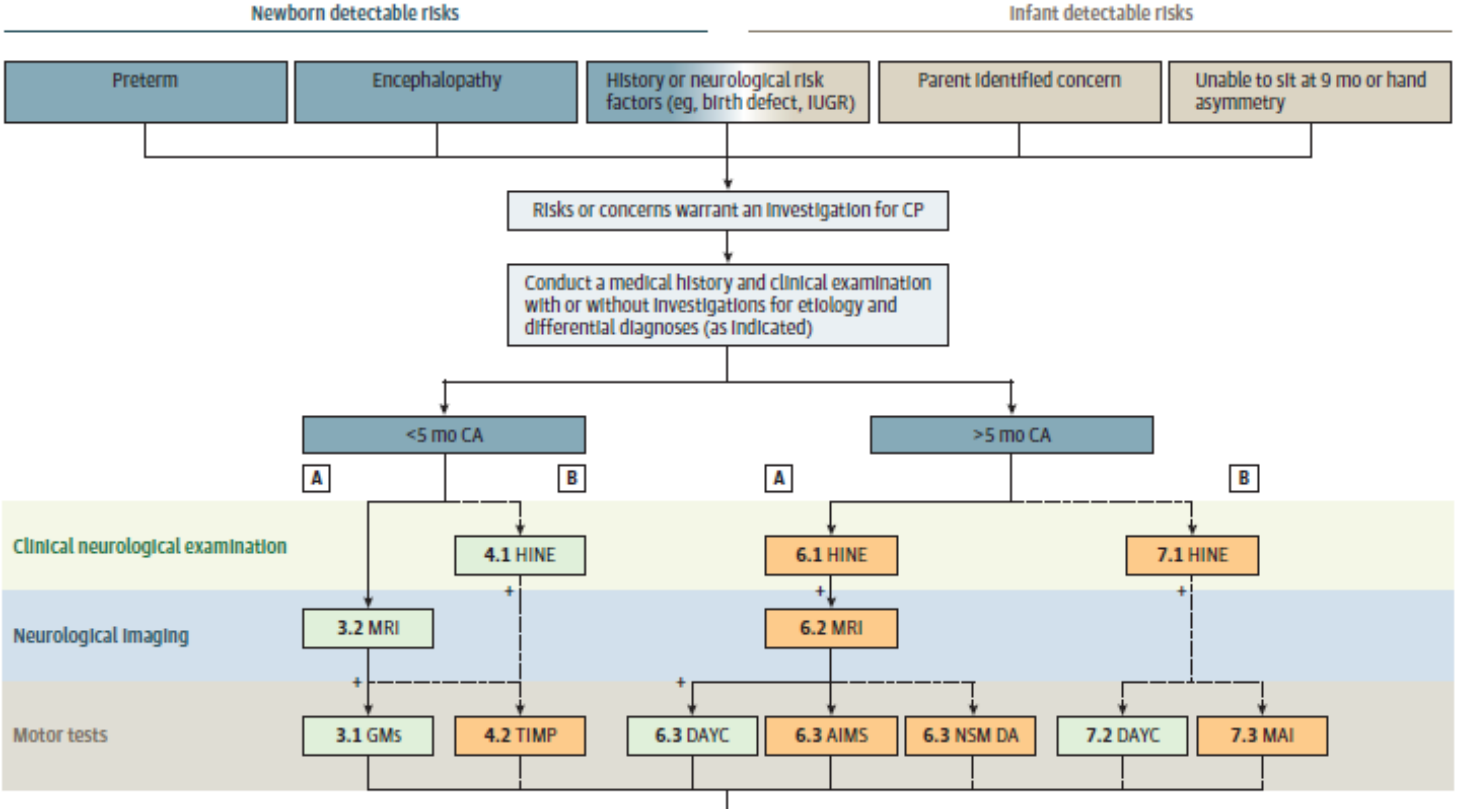
Early, Accurate Diagnosis and Early Intervention in Cerebral Palsy
Advances in Diagnosis and Treatment

Iona Novak, PhD; Cathy Morgan, PhD; Lars Adde, PhD; James Blackman, PhD; Roslyn N. Boyd, PhD; Janice Brunstrom-Hernandez, MD; Giovanni Cioni, MD; Diane Damiano, PhD; Johanna Darrah, PhD; Ann-Christin Eliasson, PhD; Linda S. de Vries, PhD; Christa Einspieler, PhD; Michael Fahey, PhD; Darcy Fehlings, PhD; Donna M. Ferriero, MD; Linda Fetters, PhD; Simona Fiori, PhD; Hans Forssberg, PhD; Andrew M. Gordon, PhD; Susan Greaves, PhD; Andrea Guzzetta, PhD; Mijna Hadders-Algra, PhD; Regina Harbourne, PhD; Angeliina Kakooza-Mwesige, PhD; Petra Karlsson, PhD; Lena Krumlinde-Sundholm, PhD; Beatrice Latal, MD; Alison Loughran-Fowlds, PhD; Nathalie Maitre, PhD; Sarah McIntyre, PhD; Ganey Nortz, MD; Lindsay Pennington, PhD; Domenico M. Romeo, PhD; Roberta Shepherd, PhD; Alicia J. Spittle, PhD; Marelle Thornton, DipEd; Jane Valentine, MRCP; Karen Walker, PhD; Robert White, MBA; Nadia Badawi, PhD

International Clinical Guideline for Early Detection of High Risk of Cerebral Palsy

JAMA Paediatrics Novak et al.

Figure. Algorithm for Early Diagnosis of Cerebral Palsy or High Risk of Cerebral Palsy



Novak et al, 2017

Australasian Cerebral Palsy Clinical Trials Network

CENTRE FOR RESEARCH EXCELLENCE

HINE Train-the-Trainer

AU/NZ HINE Training Network

In 2017 Professor Leena Haataja trained 19 clinicians to facilitate HINE workshops across Australia and NZ

cre-auscpctn.centre.uq.edu.au

AusCP-CTN CRE PARTNERS

The University Of Queensland Australia · The University of Sydney · Curtin University · The University of Auckland New Zealand · Griffith University · Cerebral Palsy Alliance Research Foundation · CSIRO · Monash University · Università di Pisa · Australian Government National Health and Medical Research Council

AU/NZ HINE Training Network

Queensland:
Jo George, **Rachel Thomas, Carly Luke,**
Kym Morris, Bernadette Shannon

NSW:
Cathy Morgan
Iona Novak
Cathryn Crowle
Michelle Juarez

Western Australia:
Jane Valentine
Kate Langdon

NZ
Anna Mackay
Sian Williams

South Australia:
Felicity Baker
Kirstie Morgan

Victoria:
Alicia Spittle, Abbey Eeles, Catherine Hough, Catherine Clancy

The Aim of the HINE

Predictive accuracy for Cerebral Palsy

Sensitivity = 90%
Specificity = 90%

Bosanquet et al. 2013 DMCN
Romeo et al. 2016 DMCN

- Differentiates between infants with mild and severe neurological disorders and typically developing infants
- Provides information about an infant's movement and learning
- Validated for infants aged 2-24m CA
- Takes 15-20 mins to complete
- Good interobserver reliability

HAMMERSMITH INFANT NEUROLOGICAL EXAMINATION (v 08.02.19)

Name	Date of birth
Gestational age	Date of examination
Chronological age / Corrected age	Head circumference

SUMMARY OF EXAMINATION
Global score (max 78)
Number of asymmetries
Behavioural score (not part of the optimality score)

Cranial nerve function	score	(max 15)
Posture	score	(max 18)
Movements	score	(max 6)
Tone	score	(max 24)
Reflexes and reactions	score	(max 15)

COMMENTS

(Throughout the exam, if a response is not optimal but not poor enough to score 1, give a score of 2)

NEUROLOGICAL EXAMINATION

ASSESSMENT OF CRANIAL NERVE FUNCTION

	score 3	2	score 1	score 0	score	Asymmetry / Comments
Facial appearance (at rest and when crying or stimulated)	Smiles or reacts to stimuli by closing eyes and grimacing		Closes eyes but not tightly, poor facial expression	Expressionless, does not react to stimuli		
Eye movements	Normal conjugate eye movements		**Intermittent** Deviation of eyes or abnormal movements	**Continuous** Deviation of eyes or abnormal movements		
Visual response Test ability to follow a black/white target	Follows the target in a complete arc		Follows target in an incomplete or asymmetrical arc	Does not follow the target		
Auditory response Test the response to a rattle	Reacts to stimuli from both sides		Doubtful reaction to stimuli or asymmetry of response	No response		
Sucking/swallowing Watch infant suck on breast or bottle. If older, ask about feeding, assoc. cough, excessive dribbling	Good suck and swallowing		Poor suck and/or swallow	No sucking reflex, no swallowing		

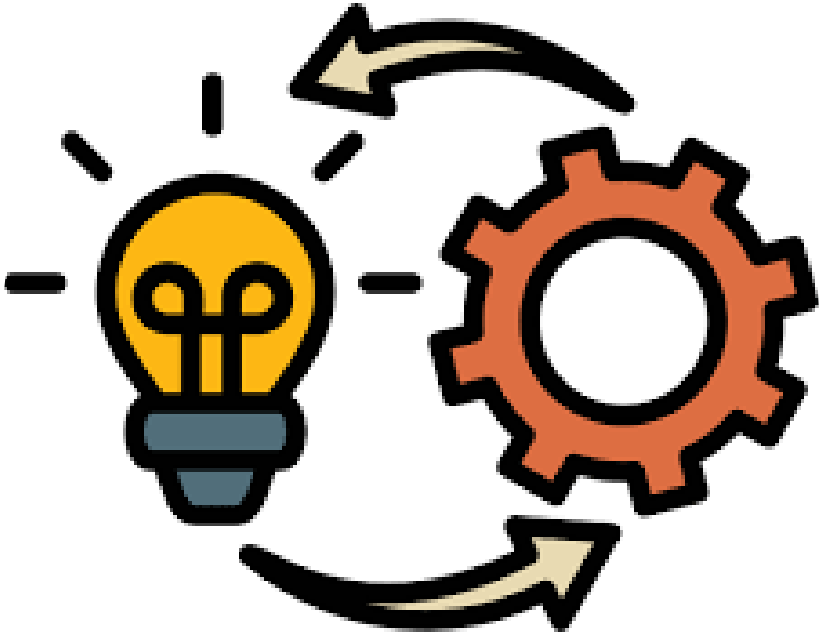
1

5 sub-sections

Global score out of 78

Age-specific cut-off scores for prediction of:

- Cerebral Palsy
  - Including functional ability (GMFCS)
- Significant cognitive delay
- Gross motor function



Integration of Guidelines into Clinical Practice...

QPRS Initial Physical Assessment Clinic (iPAC):

MDT: Paediatrician, OT, PT, SW, SLP

- 90 mins appointment
- Listen++
- Functional and objective assessments as indicated
- Essential equipment loan (e.g. seating)
- Provision of splints / first pair of orthoses

Education

- Infant-specific diagnostic information & resources
- Assessment findings – feedback to caregivers and external stakeholders
- Report - recommendations to inform NDIS, future planning, AT, intervention
- Access to health, disability and community services (e.g. ECEI/NDIS, ECDP, Vision Australia)

Connect

- Build caregiver confidence in navigating health and community supports/services
- Caregiver supports i.e. advocacy groups, Connected Care, nurse liaison, support coordinator
- Referral (e.g. MRI, Hip Surveillance, Opthalmology)
- Links (e.g. Infant Team, QEDIN-CP, CP Register)
- Referral to internal QPRS services (e.g. LAUNCH/ORBIT, CP&Related Conditions clinic)

Integration into Clinical Practice

Up-Skilling

- GMA
  - QCH/QEDIN consensus group
- HINE 'Train the Trainer'
- HINE training
- AIMS

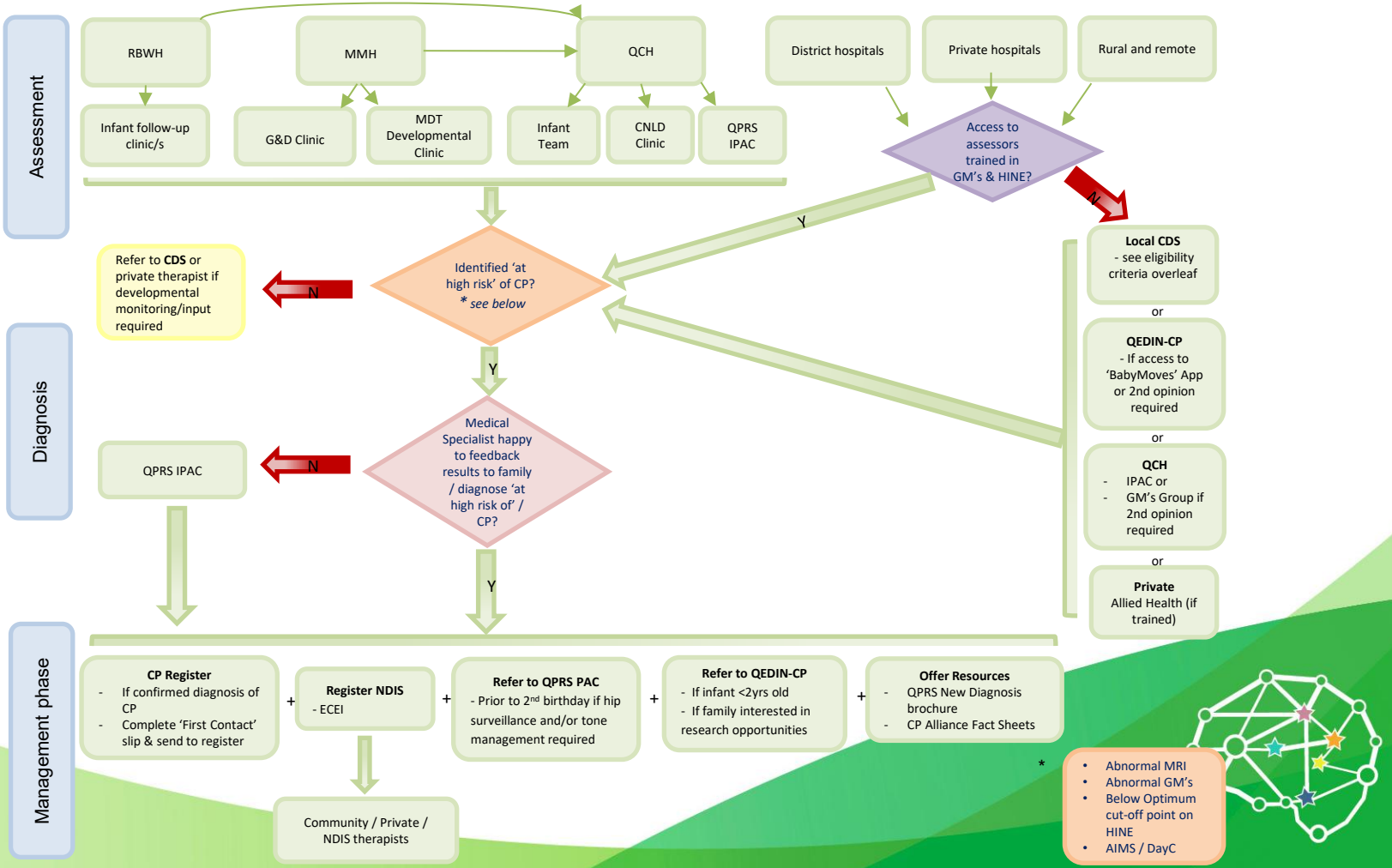
Integration

- Referral flowchart
- Feedback process
- IeMR templates (HINE)
- 'At high risk CP' diagnostic letter template (ECEI)

Quality Assurance

- SERTA Grant
- PREMs
- Consumer-informed resource development

Referral Flow for infants identified 'at risk of cerebral palsy'- Queensland Children's Hospital



Parent-reported Experience Measure

Caregiver Experience Survey
for infants identified 'at high risk of cerebral palsy'

Information about the survey
The term 'at high risk of cerebral palsy' (CP) is a provisional diagnosis given to infants to support ongoing screening and access to early intervention. We have identified that your child was given the provisional diagnosis of 'at high risk of cerebral palsy' and Children's Health Queensland would like to further understand your experience of your child receiving this diagnosis.

If you choose to take part, you will be asked questions about:

1. Your experience with the Queensland Paediatric Rehabilitation Service (QPRS)

2. Your experience of your child receiving a provisional diagnosis of 'at high risk of cerebral palsy'

What will the survey results be used for?
Your feedback will help us to improve the QPRS clinic experience and develop information resources for families.

Section 1

Part A: About your experience with Queensland Paediatric Rehabilitation Service (QPRS):

Section 2

Part B: Your experiences around your child receiving a provisional diagnosis of 'at high risk of cerebral palsy'

Consumer-informed Resources

Queensland Paediatric Rehabilitation Service

General Movements Assessment (GMA)

Information for Caregivers

What are General Movements?

General Movements are spontaneous movements that all young babies have between birth and 4-5 months of age. They are frequent and complex, involving the whole body. They vary in speed and size and change at different ages. 'Writhing' movements or 'fidgety movements' are commonly used terms which you may hear health professionals use to describe General Movements.

What is the General Movements Assessment (GMA)?

The GMA (also known as Prechtl's Qualitative Assessment of General Movements) has been well researched by several groups of respected health professionals. When used alongside some other assessments, it has strong evidence for predicting risk of neurodevelopmental concerns, in particular cerebral palsy. It is a short, 3–5-minute video of your baby's spontaneous movements whilst lying on their back when calm and relaxed. Specially trained health professionals will assess the quality and frequency of the General Movements and feedback the results to you and your baby's health care team.

'Neurodevelopmental' issues or concerns can include difficulties with movement, posture, learning or language, which may impact a baby's development in one or more areas.

Why does my child need a General Movements Assessment?

Babies who have had a stormy start to life (e.g. being born early, having a low birth weight, or requiring extra support in hospital after birth) have an increased risk of neurodevelopmental concerns. The GMA can help pick up early signs of motor delay and risks for neurological conditions such as cerebral palsy (CP). Assessment of General Movements can be completed any time from birth to 4-5 months corrected age and will help identify if your baby requires closer monitoring and early intervention.

Where should the GMA video be taken?

The GMA video may be taken while your baby is in hospital, at a therapy appointment or in your own home.

It is also possible for you to take the video of your baby and send it to a GMA-trained health professional to review. Talk to your local therapy team to see if they have trained staff who can review the videos, otherwise other options include:

Queensland Paediatric Rehabilitation Service

Hammersmith Infant Neurological Examination (HINE)

Information for Caregivers

What is the Hammersmith Infant Neurological Examination (HINE)?

The HINE is a scoreable and standardised clinical neurological examination which can be used for infants between 2 and 24 months of age.

The HINE has been well researched by several groups of respected health professionals. When used alongside other assessments (e.g. General Movements Assessment* and brain MRI) it has shown strong evidence for predicting risk of neurodevelopmental issues, in particular cerebral palsy.

'Neurodevelopmental' issues or concerns can include difficulties with movement, posture, learning or language, which may impact a baby's development in one or more areas.

What does the HINE assess?

The HINE assesses cranial nerve function (vision, movements of the face and mouth, feeding), posture (positions your baby rests in), quality and quantity of movements, muscle tone, reflexes, and reactions. It can be scored, and the maximum possible score is 78. The person who completes the assessment will also make a note of any differences between the right and left side.

Your baby's total HINE Score at different ages may help predict their 'risk' of neurodevelopmental issues, including cerebral palsy. The results of the HINE should be shared with you by your health care team, including what this means for you and your baby.

Why does my child need a HINE?

Babies who have had a stormy start to life (e.g. being born early, having a low birth weight, or requiring extra support in hospital after birth) may have an increased risk of neurodevelopmental concerns. The HINE can be performed any time from 2 months (corrected age if your baby was born prematurely) to 24 months and will help identify if your baby requires closer monitoring and early intervention.

Who completes the HINE?

Any health professional can carry out a HINE, but training and experience is recommended. The assessment takes ~15 minutes to complete. Your baby may be videoed during the assessment as this may be needed to help with scoring if there is not enough time to do this during your baby's appointment. Your health professional should discuss this with you at the time and let you know when/how the results of the HINE will be fed back to you.

Queensland Paediatric Rehabilitation Service

High Risk of Cerebral Palsy

Information for Caregivers

What is cerebral palsy?

Cerebral palsy (CP) is a movement disorder caused by an injury to an infant's brain early in life. It affects movement and posture which can in turn impact all or some areas of development. It is the most common lifelong childhood disability affecting 1 in 700 children in Australia. CP is an umbrella diagnosis with a wide-ranging spectrum of abilities and every child is affected differently.

'High risk' of cerebral palsy – what does this mean?

High risk of cerebral palsy is an interim or short-term diagnosis. It is used when there are concerns about an infant's posture and movement development, but a definite diagnosis of cerebral palsy (CP) cannot be made. The decision to diagnose your baby at high risk of CP may be based on two or more of the following:

- Medical history (e.g. difficult birth, stroke)
- Assessment of your baby (doctor and therapist)
- Prechtl's General Movements Assessment (GMA)*
- Hammersmith Infant Neurological Examination (HINE)*
- Brain imaging (e.g. cranial ultrasound, MRI)

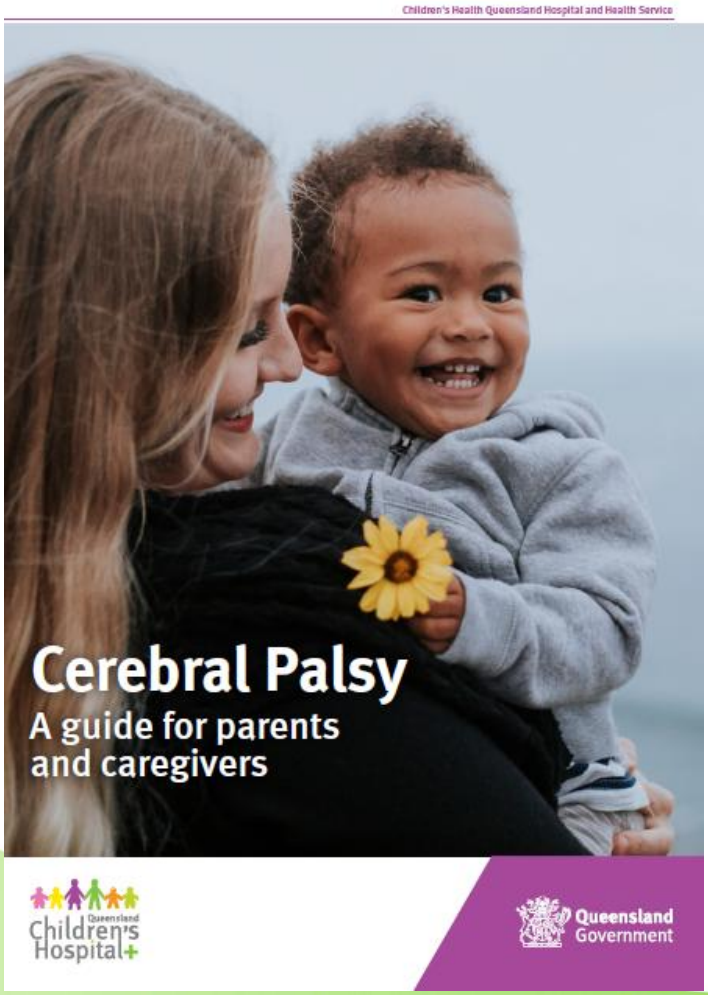
Some professionals may use the words *risk of* CP and others may say *high risk of* CP. These are just different ways of saying the same thing and doesn't mean that your baby's chances of having CP have changed.

Early diagnosis is better than a "watch and wait" approach

Evidence is strong and caregivers have told us that providing a diagnosis of high risk of cerebral palsy is much better than 'watching and waiting'. Your baby will be more closely monitored and will have access to early intervention supports, giving them the best chance to reach their potential.

Does having a diagnosis of high risk of CP mean my baby will have CP?

Having a diagnosis of high risk of CP doesn't mean that your baby will go on to receive a confirmed diagnosis of cerebral palsy. A formal diagnosis of CP will be made if your baby continues to have difficulties with their movement and posture and should be confirmed by the time your baby turns 2. Some babies may not have CP, but may continue to have difficulties with development, learning and/or behaviour. It's important to keep in touch with your General Paediatrician or GP and contact your team if you have concerns.



Contents

Version 2

Summary of Evidence

Normative data and
optimality scores

Cut-off scores and prediction of
Cerebral Palsy

- Functional abilities (GMFCS)
- Topography (uni vs bilateral)

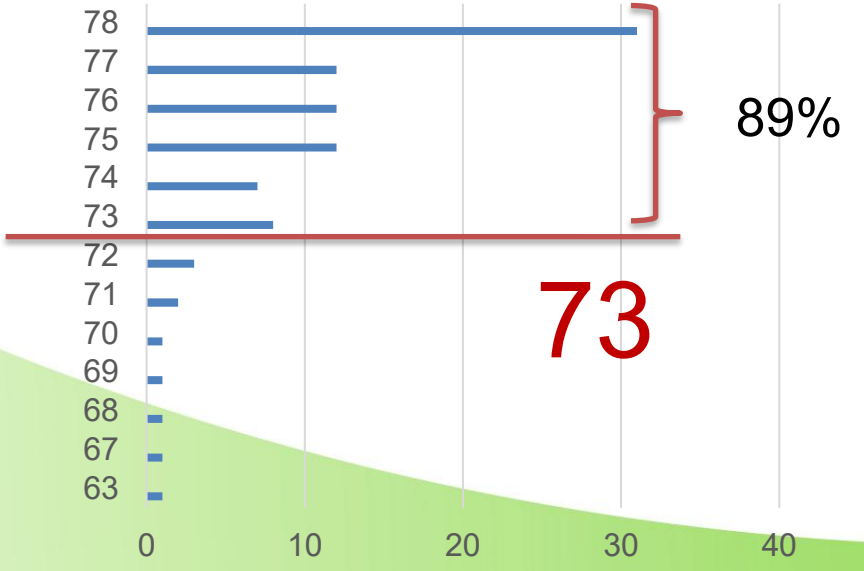
Cut-off scores and
prediction of **other**
neurodevelopmental
delay or disability

Optimality score for the neurologic examination of the infant at 12 and 18 months of age

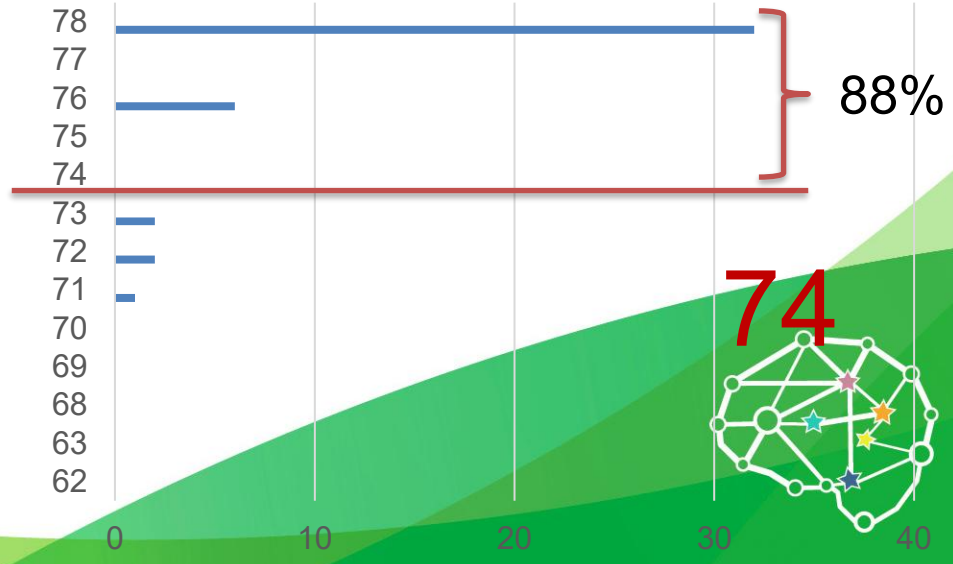
Leena Haataja, MD, PhD, Eugenio Mercuri, MD, PhD, Rivka Regev, MD, Frances Cowan, MBBS, MRCP, PhD, Mary Rutherford, MD, MRCP, Victor Dubowitz, MD, FRCPCH, PhD, and Lilly Dubowitz, MD, FRCPCH

J Pediatr
1999;135:153-61

12 months n=92



18 months n=43



Optimality ranges for preterm compared to term-born infants

Median (range) global scores in low-risk **very preterm (≤32 weeks)**, **late preterm (33-36 weeks)** and **term** born infants.

Age	3 months	6 months	9 months	12 months
Term infants (n=69)	65.5 (62-69)	69 (64-74)	72.5 (65-78)	74 (65-78)
Late preterm (33-36/40) infants (n=71)	62 (57-69)	66 (60-72)	71 (63-75)	73 (64-77)
Very preterm (≤32/40) infants (n=48)	62 (51-67)	66 (52-71)	70 (57-76)	72 (60-77)

Prediction of CP

DEVELOPMENTAL MEDICINE & CHILD NEUROLOGY REVIEW

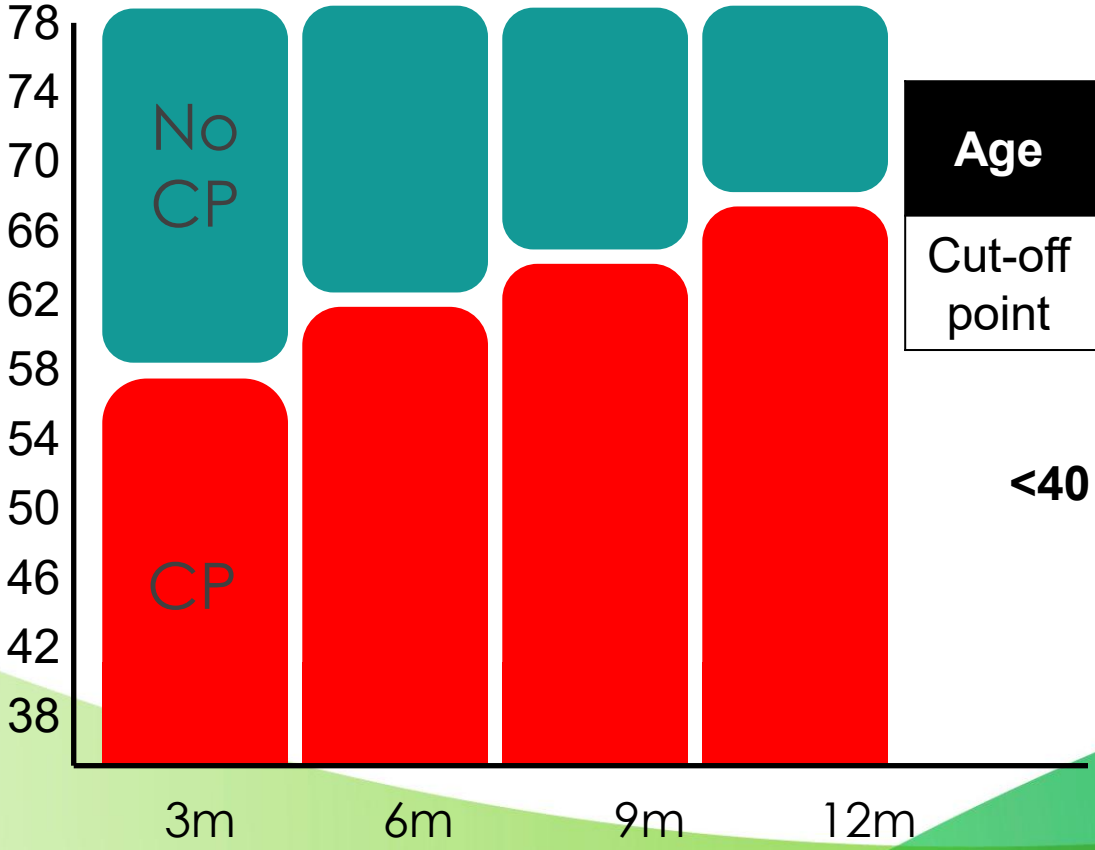
Use of the Hammersmith Infant Neurological Examination in infants with cerebral palsy: a critical review of the literature

DOMENICO M ROMEO | DANIELA RICCI | CLAUDIA BROGNA | EUGENIO MERCURI

2016

The Hammersmith Infant Neurological Examination (HINE) has been proposed as one of the early neurological examination tools for the diagnosis of cerebral palsy (CP). The aim of the present study was to critically review the existing literature and our experience with the use of the HINE in infants at risk of CP. The published papers confirm that the HINE can play an important role in the diagnosis and prognosis of infants at risk of developing CP, and provide information on aspects of neurological findings impaired in different forms of CP and brain lesions.

Prediction of CP



Age	3 mths	6 mths	9 mths	12 mths
Cut-off point	<57	<60	<63	<66

<40 only found in association with severe CP

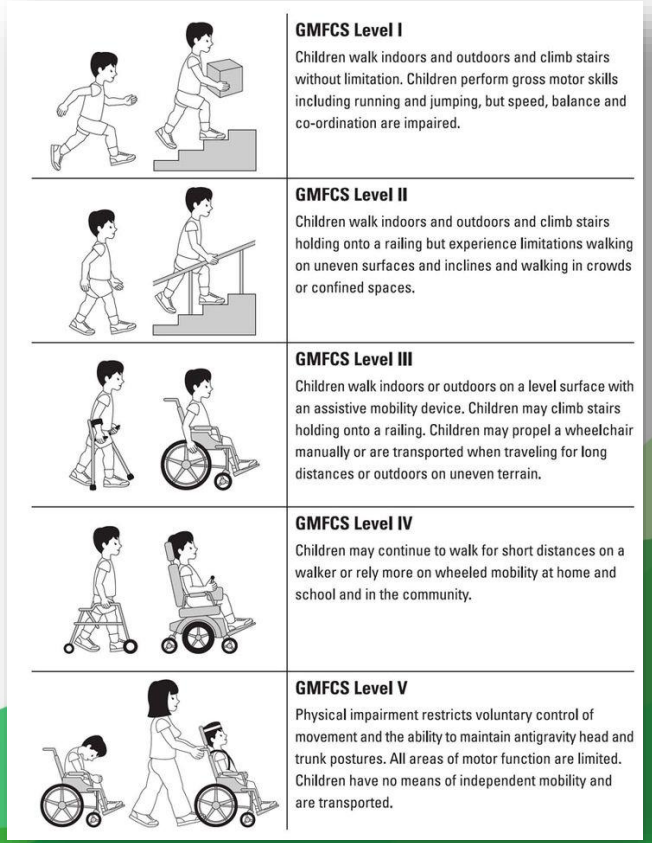
Functional abilities in CP

Romeo et al 2008 Eur J Ped Neurol; n=70 all CP

<40	40-60
GMFCS level IV-V (+ severe diplegia III)	GMFCS level I-II (diplegia, hemiplegia)

Note:

- **<40** only seen in severe CP
- 26 % of infants with hemiplegia scored ≥ 67 at 12 months
- Sequential examinations recommended!



GMFCS Level I

Children walk indoors and outdoors and climb stairs without limitation. Children perform gross motor skills including running and jumping, but speed, balance and co-ordination are impaired.

GMFCS Level II

Children walk indoors and outdoors and climb stairs holding onto a railing but experience limitations walking on uneven surfaces and inclines and walking in crowds or confined spaces.

GMFCS Level III

Children walk indoors or outdoors on a level surface with an assistive mobility device. Children may climb stairs holding onto a railing. Children may propel a wheelchair manually or are transported when traveling for long distances or outdoors on uneven terrain.

GMFCS Level IV

Children may continue to walk for short distances on a walker or rely more on wheeled mobility at home and school and in the community.

GMFCS Level V

Physical impairment restricts voluntary control of movement and the ability to maintain antigravity head and trunk postures. All areas of motor function are limited. Children have no means of independent mobility and are transported.

HINE Asymmetry Score: Study 1

Hay *et al*, Paediatric Neurology, 2018

Hammersmith Infant Neurological Examination Asymmetry Score Distinguishes Hemiplegic Cerebral Palsy From Typical Development

Krystal Hay DPT [a], MaryAnn Nelin MD [a], Helen Carey PT [a], Olena Chorna MM, CCRP [a], Melissa Moore-Clingenpeel, MA, MAS [c], Nathalie Maitre MD, PhD [a b], NCH Early Developmental Group

n=148 infants included:

74 with CP: 35 hemiplegia, 11 diplegia, 28 quadriplegia

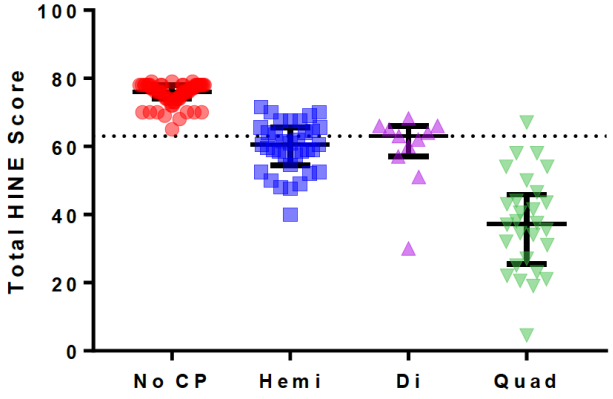
N=74 control

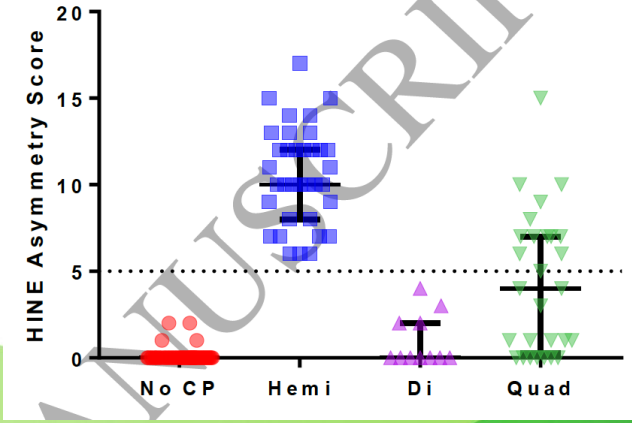
- Compared children with CP with GA matched infants with typically developing outcome
- Each item scored

  0 = no asymmetry

  1= asymmetry present

HINE scores & distribution of CP





HINE global score <63 **OR** asymmetry score >5 was predictive of unilateral CP

(Se=92%, Sp=100%)

Asymmetry scores add to the utility of the HINE and may differentiate milder forms of CP from other NDD

Limitations of the study

- Not clear if >5 asymmetry is overall or specific to 1 side
- Median age of infant at HINE assessment was 10-17m (8-22m), need to look at a younger cohort to understand predictive value of asymmetries for later unilateral CP.

HINE Asymmetry Score: Study 2

Pietruszewski *et al*, Paediatric Physical Therapy, 2021

Hammersmith Infant Neurological Examination Clinical Use to Recommend Therapist Assessment of Functional Hand Asymmetries

Lindsay Pietruszewski, PT, DPT; Mary Ann Nelin, MD; Nancy Batterson, OT/L, SCFES, CLC; Julia Less, MPH; Melissa Moore-Clingenpeel, MA, MAS; Dennis Lewandowski, PhD; Katelyn Levengood, PT, DPT; Nathalie L. Maitre, MD, PhD

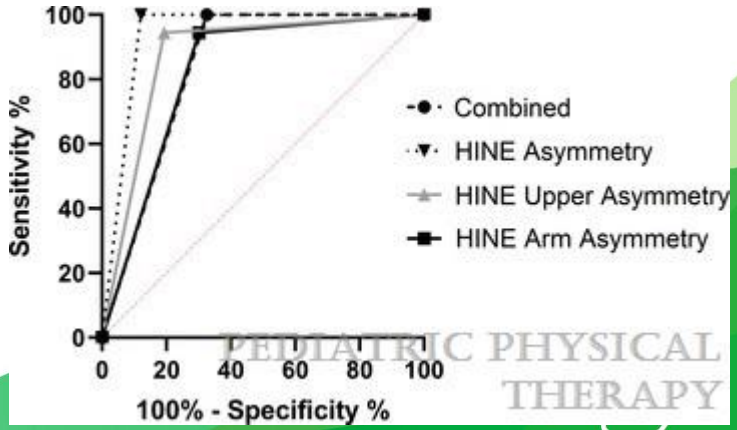
Center for Perinatal Research at the Abigail Wexner Research Institute at Nationwide Children's Hospital, Columbus, Ohio (Drs Pietruszewski, Nelin, Lewandowski, Levengood, and Maitre and Mss Batterson and Less); Department of Pediatrics (Drs Nelin and Maitre), Nationwide Children's Hospital, Columbus, Ohio; Biostatistics Core at the Abigail Wexner Research Institute at Nationwide Children's Hospital, Columbus, Ohio (Ms Moore-Clingenpeel).

Aim: can asymmetry scores on the HINE identify infants with a ≥3 pt between hand difference on the Hand Assessment of Infants (HAI)

n=101 infants included

HINE and HAI administered concurrently at 3 to 12m (av age 7.6m CA)

- 4 or more asymmetries was predictive of ≥3pt difference on HAI (Se=100%, Sp=88%)
- Predictive accuracy improved when HINE was administered after 4m CA.



HINE and non-CP outcomes

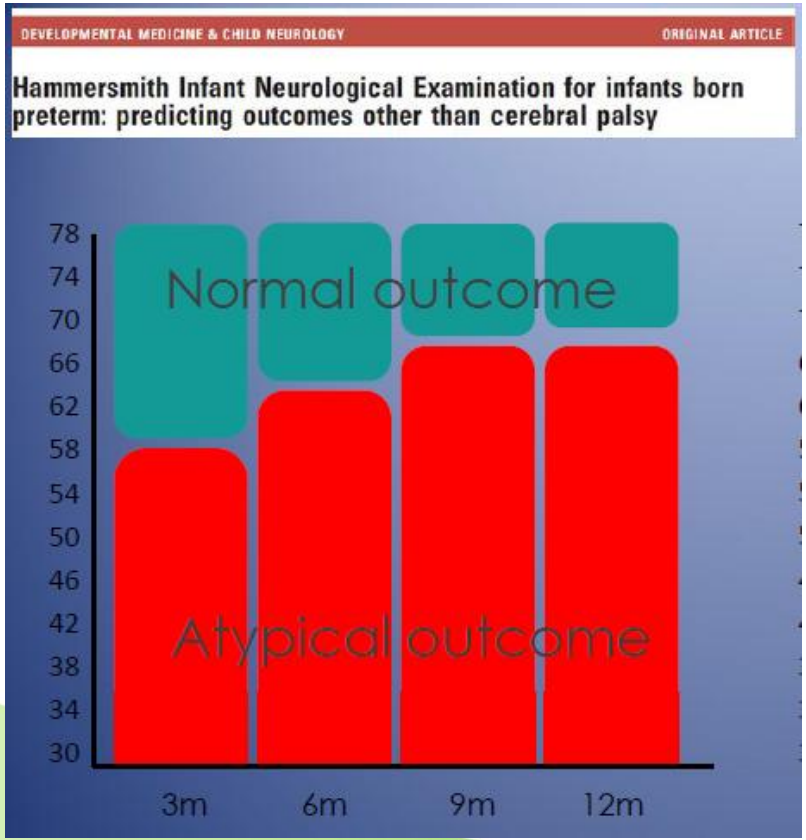
DEVELOPMENTAL MEDICINE & CHILD NEUROLOGY ORIGINAL ARTICLE

Hammersmith Infant Neurological Examination for infants born preterm: predicting outcomes other than cerebral palsy

DOMENICO M ROMEO[1,2] | FRANCES M COWAN[3] | LEENA HAATAJA[4] | DANIELA RICCI[1,5] | ELISA PEDE[2] | FRANCESCA GALLINI[6] | FRANCESCO COTA[6] | CLAUDIA BROGNA[1] | GIOVANNI VENTO[6] | MARIO G ROMEO[7] | EUGENIO MERCURI[1,2]

1 Pediatric Neurology Unit, Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome; **2** Pediatric Neurology Unit, Università Cattolica del Sacro Cuore Roma, Rome, Italy. **3** Department of Paediatrics, Imperial College, London, UK. **4** Division of Pediatric Neurology, Children's Hospital, Pediatric Research Center, University of Helsinki, Helsinki, Finland. **5** National Centre of Services and Research for the Prevention of Blindness and Rehabilitation of Low Vision Patients, IAPB Italia Onlus, Rome; **6** Neonatal Intensive Care Unit, Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome; **7** Neonatal Intensive Care Unit, Department of Paediatrics, University of Catania, Catania, Italy.

Prediction of ‘significant delay’ and/or CP



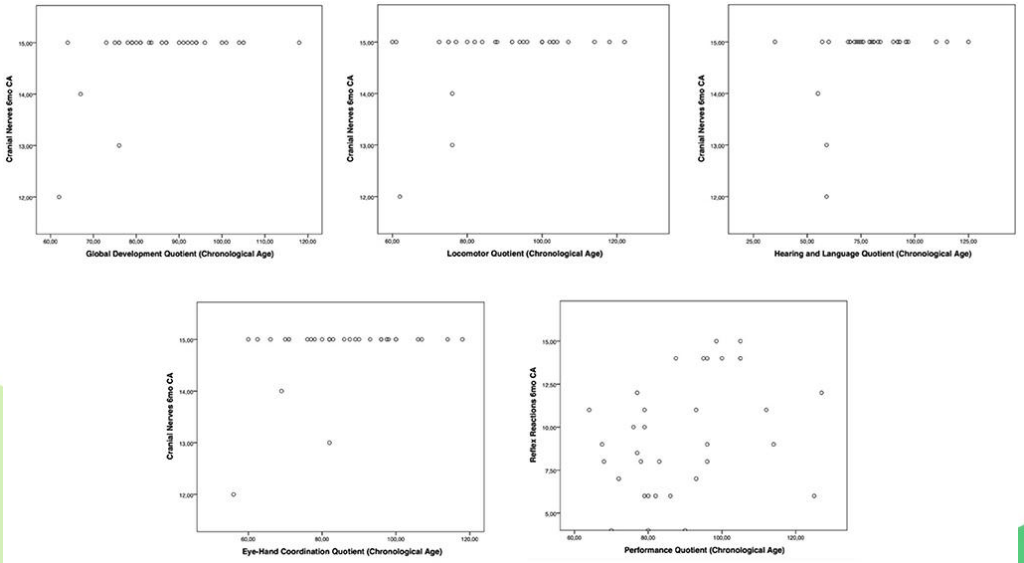
Age at assessment	Cut-off	Normal/mildly delayed (n=891) vs Significantly delayed (n=217)
3 months CA	58	Se 51- Sp 90 (AUC 0.71; Accuracy 0.83)
6 months CA	64	Se 81- Sp 71 (AUC 0.76; Accuracy 0.73)
9 months CA	69	Se 82- Sp 81 (AUC 0.82; Accuracy 0.81)
12 months CA	69	Se 76- Sp 93 (AUC 0.85; Accuracy 0.90)

Romeo et al. 2020 n= 1229, infants born <37 weeks, follow up at 2 years

HINE <9m prediction of motor and cognitive outcomes at 2 years

Long-term predictivity of early neurological assessment and developmental trajectories in low-risk preterm infants

Daniela Dicanio [1], Giulia Spoto [1], Angela Alibrandi [2], Roberta Minutoli [1], Antonio Gennaro Nicotera [1], Gabriella Di Rosa [1]

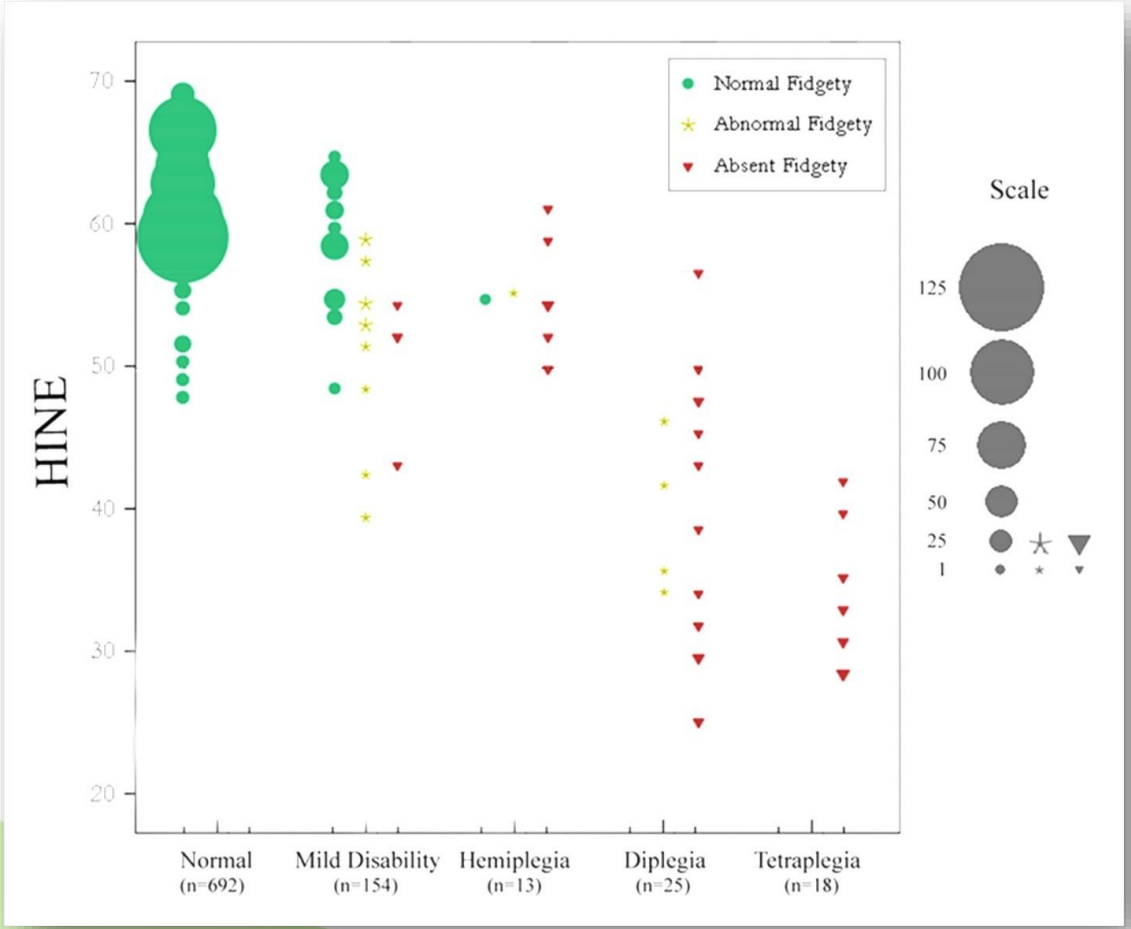


n=148 infants born preterm

Predictive accuracy of HINE (3-9m) to predict development on the GMDS at 2 years CA

- Scores on 'movements' at 3, 6 and 9 months were associated with locomotor at 2 years. Association strengthened with age
- Scores on 'posture' at 6 m also associated with locomotor.
- Cranial nerve function at 6m demonstrated correlation with development, locomotor, eye-hand coordination and hearing and language

The importance of triangulation of assessment results



EUROPEAN JOURNAL OF PAEDIATRIC NEUROLOGY 12 (2008) 183–189

ELSEVIER

Official Journal of the European Paediatric Neurology Society

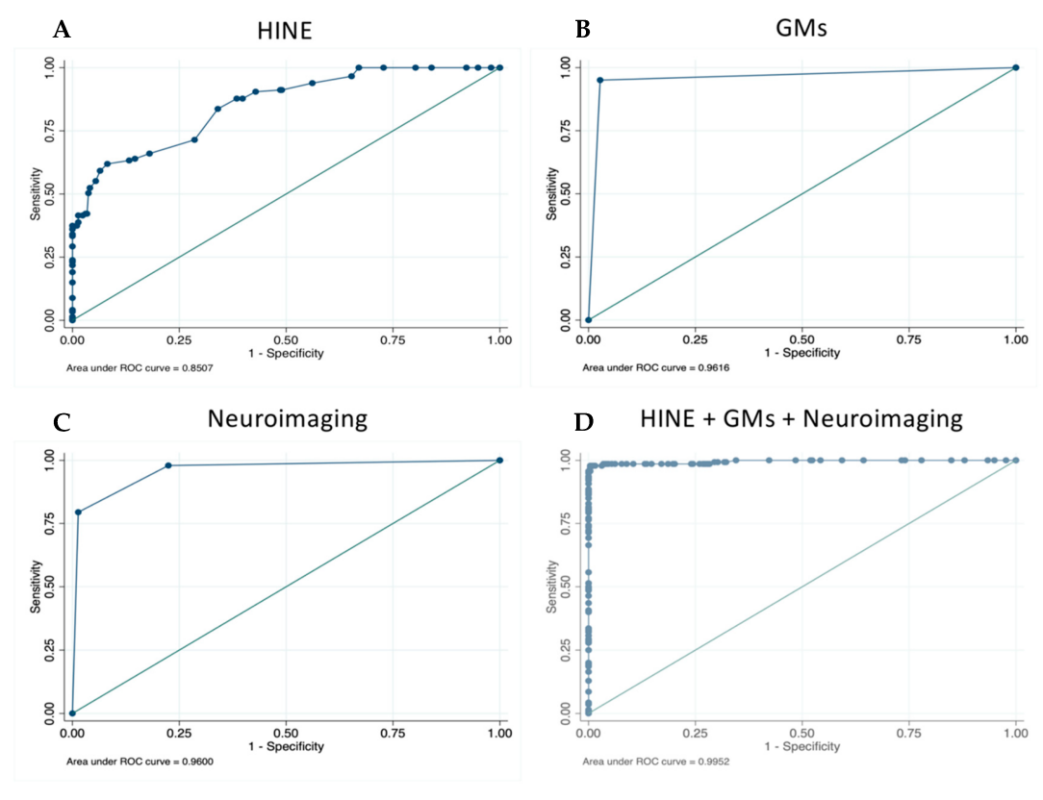
Original article

Early neurologic assessment in preterm-infants: Integration of traditional neurologic examination and observation of general movements

Domenico Marco Maurizio Romeo[a], Andrea Guzzetta[b,], Mariacristina Scoto[a], Matteo Cioni[a,c], Pietro Patusi[d], Domenico Mazzone[a], Mario Giuseppe Romeo[e]*

903 preterm infants:

- Inclusion: infants with a GA<37 weeks
- Exclusion: presence of genetic disorders or congenital malformations



Journal of *Clinical Medicine*

MDPI

Article

The Pooled Diagnostic Accuracy of Neuroimaging, General Movements, and Neurological Examination for Diagnosing Cerebral Palsy Early in High-Risk Infants: A Case Control Study

Catherine Morgan [1,*], Domenico M. Romeo [2], Olena Chorna [3], Iona Novak [1], Claire Galea [1,4], Sabrina Del Secco [3] and Andrea Guzzetta [3,5]

441 high risk infants:

3-month HINE, GMs and neuroimaging

- HINE accuracy for CP = Se=88%, Sp=62%, **Accuracy=82.1%**
- Pooled prediction of GMs+ HINE + neuroimaging Se=97.9%, Sp=99.2%, **Accuracy=98.75**

New and emerging evidence

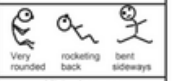
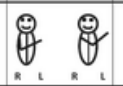
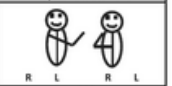
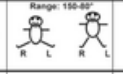
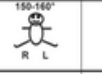
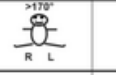
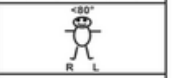
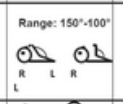
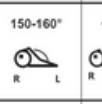
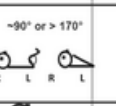
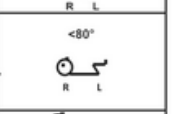
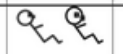
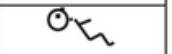
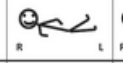
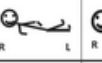
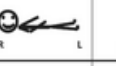
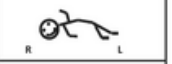
Brief-HINE

Name
Date of examination
Global score (max 33)

Date of birth

Gestational Age
Head circumference
Number of asymmetries

Chronological age/Corrected age

	Score 3	Score 2	Score 1	Score 0
Visual response test ability to follow a black/white target	Follows the target in a complete arc		Follows the target in an incomplete or asymmetrical arc	Does not follow the target
Trunk in sitting	 Straight		 Slightly curved or bent to side	 Very rounded · rocketing back · bent sideways
Quantity of movements Watch infant lying in supine	Normal		Excessive or sluggish	Minimal or none
Quality of movements Observe infant's spontaneous voluntary motor activity during the course of the assessment	Free, alternating, and smooth		Jerky, Slight tremor	• Cramped & synchronous • Extensor spasms • Athetoid • Ataxic • Very tremulous • Myoclonic spasm • Dystonic movement
Scarf sign Take the infant's wrist, pull the arm across the chest till there is resistance. Note the position of elbow in relation to the midline.	 R L R L		 R L	 R L R L
Hip adductors With both the infant's legs extended, abduct them as far as possible. The angle formed by the legs is noted	 Range: 150-80° R L R L	 150-160° R L	 >170° R L	 <80° R L
Popliteal angle Keep the infant's bottom on the bed, flex both hips onto the abdomen, then extend knees till resistance felt. Note the angle between the upper and lower leg	 Range: 150°-100° R L R L	 150-160° R L	 ~90° or > 170° R L R L	 <80° R L
Pull to sit Pull infant to sit by the wrists. (support head if necessary)				
Lateral tilting Hold the infant up vertically near to the hips and tilt slowly sideways towards the horizontal. Note response of trunk, spine, limbs and head.	 R L	 R L	 R L	 R L
Forward parachute Hold infant up vertically and quickly tilt forward. Note reaction and symmetry of arm responses	 After 6 months		 After 6 months	
Tendon Reflexes Have child relaxed, sitting or lying -use small hammer	easily elicitable biceps knee ankle	mildly brisk bicep knee ankle	brisk biceps knee ankle	clonus or absent biceps knee ankle

DMCN Developmental Medicine & Child Neurology

ORIGINAL ARTICLE | Open Access

Neurological assessment tool for screening infants during the first year after birth: The Brief-Hammersmith Infant Neurological Examination

Domenico M. Romeo, Chiara Velli, Francesca Sini, Elisa Pede, Graziamaria Cicala, Frances M. Cowan, Daniela Ricci, Claudia Brogna, Eugenio Mercuri

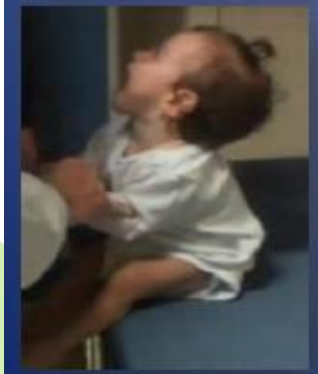
A shortened version of the original HINE

- **11 items** – from HINE found to be most predictive of CP in low and high-risk infants
- Cut-off scores for 3, 6, 9 and 12 months corrected age for high-risk of CP

Scan for Access to the Brief-HINE

Brain damage and CP ***early signs < 6mo***

Persistent increased extension tone



Popliteal angle <90°

Flexed arms extended legs

Abductor angle <80°

Visual function impairment

Brain damage and CP *late signs > 6mo*

Late acquisition of parachute reaction

Abnormal arm protection

Asymmetry of lateral tilting

Brief-HINE

Age at Assessment	Cut-off Score	Diagnostic accuracy for CP
3 months	<22	Se 88%, Sp 92%
6 months	<25	Se 93%, Sp 87%
9 months	<27	Se 95%, Sp 81%
12 months	<27	Se 100%, Sp 86%

Cohort of n=310 infants with 2-year outcomes
n=228 infants with typical development at 2 years
n=82 infants with CP at 2 years

Clinician Scoring Aid

D Fehlings, A Makino, P. Church, R Banihani, K Thomas, M Luther, S Lam-Damji, B Vollmer, L Haataja,
FM Cowan, DM Romeo, JM George, S Kumar, L Switzer (May 2024)

Name:_____
MRN:_____
Date of Birth:_____

Hammersmith Infant Neurological Examination (HINE): Score Interpretation Aid for Children Receiving Neonatal Follow-Up Care

Clinical history: _____

Brain imaging (if available): _____

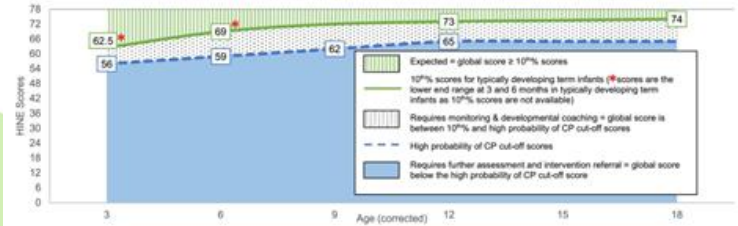
Visit	Child's Age (corrected)	Child's Global HINE Score	HINE Asymmetry Score	Corrected Age for GMA (if available)	GMA Category (if available)	Interpretation/Action	Discussed with family
1							☐
2							☐
3							☐
4							☐
5							☐

HINE Scoring Aid Reference Information:

- Interpret HINE scores with clinical reasoning (e.g., term versus preterm, risk factors for CP, health co-morbidities, brain imaging, and General Movements Assessment (GMA)) when comparing to those from typically developing term infants. Follow the trajectory of HINE scores over time.
- The table provides expected global scores (median/ranges) for term[1,2] (column 2) and preterm infants[3,4] of various gestational ages (column 3,4) with typical 2-year development. 10th percentile scores (optimality scores) (equal to or above) which infants are considered to have typical neurological performance[3,4] is provided where available (column 2,4).
- Typically developing preterm infants have median global scores that range from 9 points at 3 months to 3.5 points at 12 months lower than typically developing term-born infants (column 3,4)[3,4]. There is also a wider range of scores around the median in preterms.
- CP cut-off scores (column 5) are global scores below which term and preterm infants with etiologic risk for CP (e.g., preterm, neonatal encephalopathy) have a high probability of developing CP[5]. Refer for early intervention.
- Infants with unilateral CP may not have low global scores but can have ≥4 asymmetries representing significant asymmetric neurologic performance[6]. Refer for early intervention if ≥4 asymmetries are present regardless of infant's age.

Column 1	Column 2 Global scores for typically developing term born infants[1,2]	Column 3 Global scores for low-risk LPT and VPT infants[3]	Column 4 Global scores for low-risk EPT infants[4]	Column 5 Cut-off scores for high probability of CP[5]
Child's Age (corrected)	37-42 weeks GA Median (range)	mean GA 32 weeks (range 27-36) Median (range)	mean GA 27 weeks (range 23-31) Median (range)	All birth gestational ages but definitive data not available for EPT infants
3 months	**67** (62.5*-69)[2]	**62** (51-69)[3]	**58** (47-69) (10th% 53)[4]	≤56 (sen 96% sp 85%)[5]
6 months	**73** (69*-76.5)[2]	**66** (52-72)[3]	**67** (54-76) (10th% 62)[4]	≤59 (sen 90% sp 89%)[5]
9 months	*N/A*	**70.5** (57-76)[3]	**71.5** (62-78) (10th% 67)[4]	≤62 (sen 90% sp 91%)[5]
12 months	**76** (63-78) (10th% ≥73)[1]	**72.5** (60-77)[3]	**73.5** (67-78) (10th% 70)[4]	≤65 (sen 91% sp 90%)[5]
18 months	**78** (71-78) (10th% ≥74)[1]	*N/A*	*N/A*	*N/A*
	10th percentile scores (10th%); 90% of infants score at or above this level. * See legend in graph below.	Data for LPT and VPT infants are combined – medians are similar, but the range span is narrower for LPT than VPT	Note median scores are considerably lower for EPT infants than FT, LPT and VPT infants at 3 months.	A global score <40 at any age is highly predictive of CP GMFCS III-V at 2 years of age[7].

N/A not available, Low-risk - no additional CP etiologic risk aside from being preterm[3,4],LPT Late preterm 33-36 weeks gestational age (GA), VPT very preterm 27-32 weeks GA, EPT extremely preterm (23 -31 weeks GA) as defined in this study[4], sen (sensitivity), sp (specificity)



DMCN Developmental Medicine & Child Neurology

LETTER TO THE EDITOR | Open Access

The Hammersmith Infant Neurological Exam Scoring Aid supports early detection for infants with high probability of cerebral palsy

Darcy Fehlings, Amber Makino, Paige Church, Rudaina Banihani, Karen Thomas, Maureen Luther, Sophie Lam-Damji, Brigitte Vollmer, Leena Haataja ... See all authors

First published: 31 May 2024 | https://doi.org/10.1111/dmcn.15977

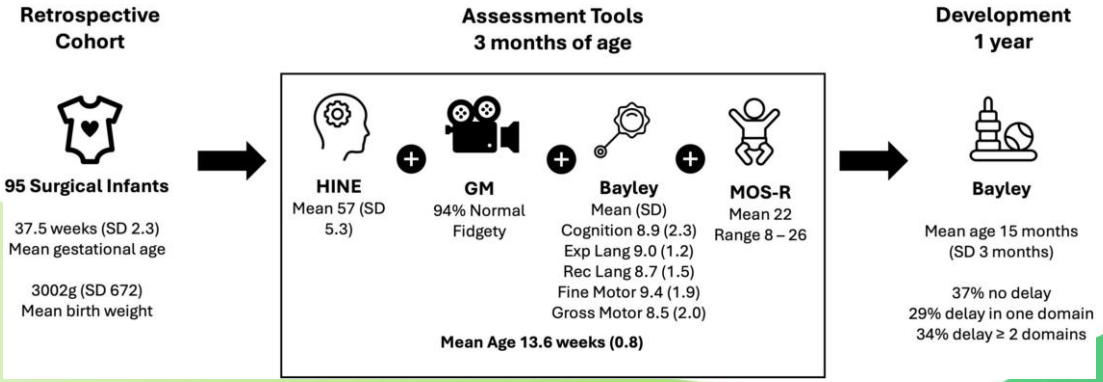
Scan for Access to the HINE Score Interpretation Aid

Predictive value of the HINE at 3m

Early Human Development
Volume 203, April 2025, 106226

The predictive validity of HINE, Bayley, general movements and MOS-R in infancy

Michelle Jackman [a b c], Catherine Morgan [a c], Carly Luke [d], Larissa Korostenski [b], Katya Zawada [b], Michelle Juarez [e], Annabel Webb [a], Remy Blatch-Williams [a], Cathryn Crowle [c e]



- 3 month HINE <60 best predicted delays in ≥ 2 Bayley 3 domains (Se=84%, Sp=46%)
- 3 month HINE <60 best predicted delays cognitive delays (Se=89%, Sp=38%)
- Both demonstrated low specificity suggesting a high number of false positives
- Combining the HINE with 3m Bayley slightly improved predictive value

Scan for full paper – Early Human Development

Transdiagnostic utility of HINE for neurodevelopmental disability or delay

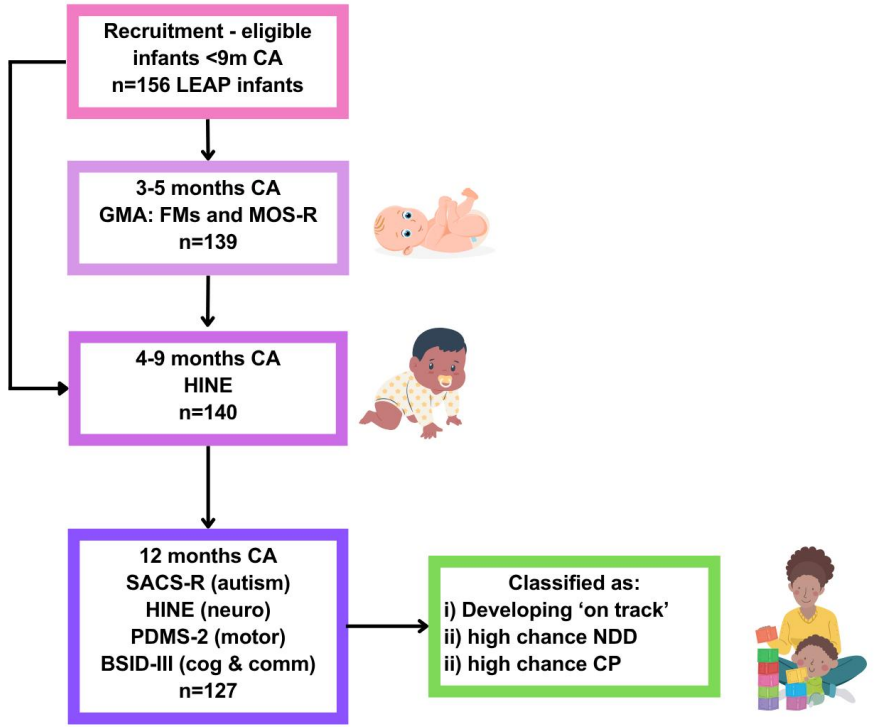
DMCN Developmental Medicine & Child Neurology

ORIGINAL ARTICLE | Open Access

Predicting neurodevelopmental outcomes in Australian First Nations infants: The transdiagnostic utility of early screening tools

Carly Luke, Katherine A. Benfer, Leeann Mick-Ramsamy, Robert S. Ware, Margot Bosanquet, Natasha Reid, Arend F. Bos, Roslyn N. Boyd, Queensland State-wide LEAP Clinical Group

Scan for LEAP predictive Outcomes paper



Diagnostic accuracy of HINE for NDD/CP

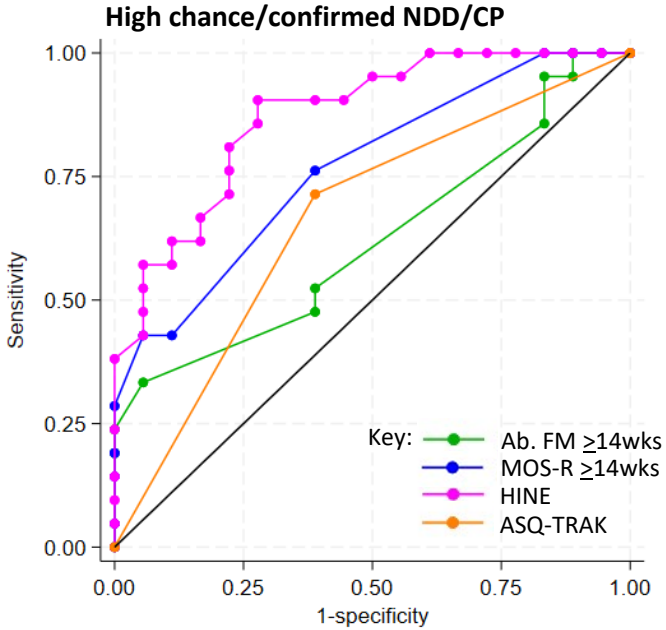
THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Key Findings

Mod – severely reduced HINE
demonstrated greatest overall prediction, correctly classified 72% of infants at 12 months

<23 **<sig. delay**

Combined trajectory of low MOS-R and HINE
Decreased the number of false positives, correctly classifying 74% of infants at 2 years.



Recommended tool/s and cut-off score	Timing	Diagnostic accuracy % (95% CI)
MOS-R (<23)	14-16 weeks	Se= 84% Sp=38% Accuracy=64% (54-74)
HINE (<sig delay)	4-9 months	Se=64% Sp=84% Accuracy=72% (63-80)
Trajectory MOS-R (<23) + HINE (<sig delay)		Se=62% Sp=93% Accuracy=74% (65-82)

High chance of autism & FASD

High chance/confirmed autism (SACS-R)
n= 33

Trajectory → MOS-R<23 + HINE <10th centile

Accuracy= 80% (Se=59%, Sp=95%, PPV=89%)

Odds 18x high than dev. 'on track'

High chance/confirmed FASD
n= 9

Trajectory → MOS-R<22 + HINE <sig. delay cut-off

Accuracy= 92% (Se=89%, Sp=93% PPV=73%)

Odds 104x high than dev. 'on track'

HINE <12m prediction of specific-NDD

HINE total and sub-section scores 4-9 months

Infants **'on track'** (68.5) scored **significantly higher** on HINE than infants' high chance of **CP** (44.8) and **autism** (59.7)

ASSESSMENT OF MOVEMENTS

	Score 3	Score 2	Score 1	Score 0	score	Asymmetry / comments
Quantity Watch infant lying in supine	Normal		Excessive or sluggish	Minimal or none		
Quality Observe infant's spontaneous voluntary motor activity during the course of the assessment	Free, alternating, and smooth		Jerky Slight tremor	• Cramped & synchronous • Extensor spasms • Athetoid • Ataxic • Very tremulous • Myoclonic spasm • Dystonic movement		

Increased odds of by **high-autism 78%***

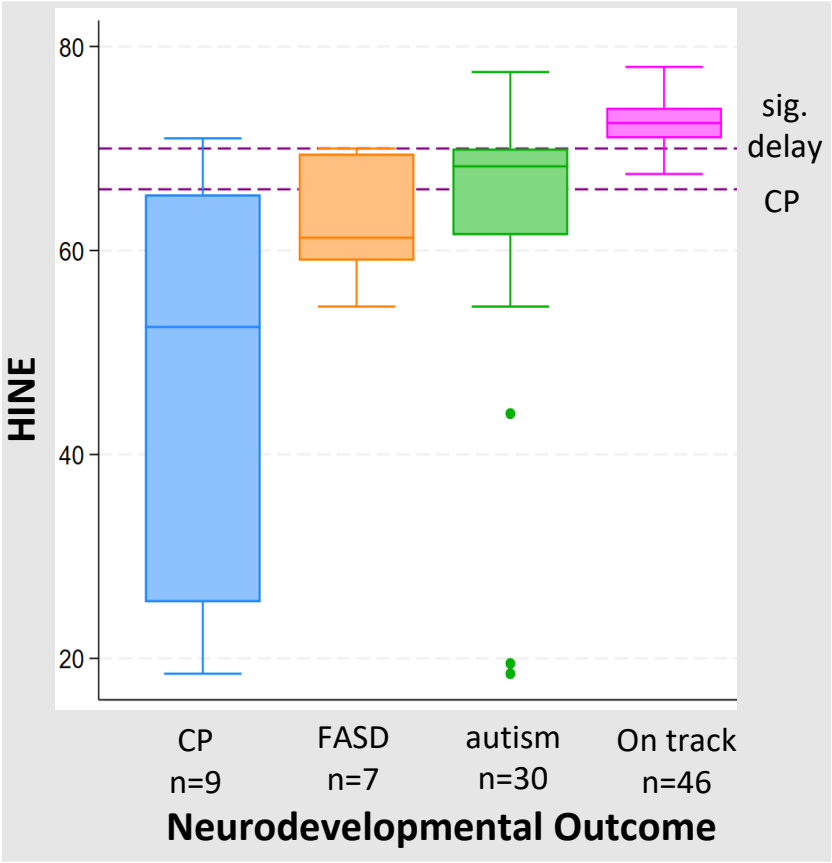
REFLEXES AND REACTIONS

	Score 3	Score 2	Score 1	Score 0	sc	Asym / Co
Arm protection Pull the infant by one arm from the supine position (steady the contralateral hip) and note the reaction of arm on opposite side.	Arm & hand extend R L		Arm semi-flexed R L	Arm fully flexed R L		
Vertical suspension hold infant under axilla making sure legs do not touch any surface – you may "tickle" feet to stimulate kicking.	Kicks symmetrically		Kicks one leg more or poor kicking	No kicking even if stimulated or scissoring		
Lateral tilting (describe side up). Hold infant up vertically near to hips and tilt sideways towards the horizontal. Note response of trunk, spine, limbs and head.	R L	L R	R L	R L		
Forward parachute Hold infant up vertically and quickly tilt forwards. Note reaction /symmetry of arm responses,	(after 6 months)		(after 6 months)			
Tendon Reflexes Have child relaxed, sitting or lying – use small hammer	Easily elicitable biceps knee ankle	Mildly brisk bicep knee ankle	Brisk biceps knee ankle	Clonus or absent biceps knee ankle		

Increased odds of **high-autism** by **22%***

*compared to developing 'on track'

HINE 12m scores by outcome



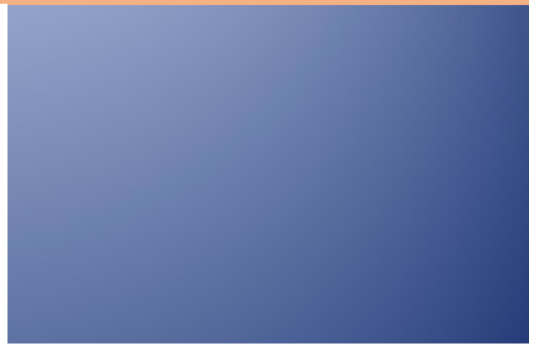
In summary:

- Standardized neurological assessment
  - can be used in **any populations** of children with neurological abnormalities requiring assessment & monitoring
- **Triangulation of findings** is critical when interpreting HINE scores
  - Published cut off scores vary between studies & definitions of CP vary across the world. The ranges of scores are important to consider as well as the cut-offs
  - Consider the asymmetry score >5 coupled with a HINE score <63 for hemiplegia
  - a low HINE score in the absence of any other risk factors for CP (eg absent fidgety or neuroimaging) is unlikely to be used to give a diagnosis of CP **– but may be indicative other non-CP neurodisability or delay**
  - A combination of tools over multiple timepoints to gain a developmental trajectory and considering clinical history is important when interpreting scores
- **Timing is important**
  - **HINE at 3 months** is less predictive of non-CP outcomes than 6 months or later

The aim of neurological examination is to detect neurological abnormalities.

"No assessment correctly identifies
all children
as having normal
or atypical development
with a single assessment."

(Heineman KR, Hadders-Algra M 2008)



<u>Sequential examinations necessary</u>

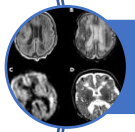
-> to detect recovery

-> to detect persistence of abnormal findings

-> for diagnostic process

Diagnosis of high-risk CP and other neurodisability or delay: Triangulation of results

Abnormal GMA (absent fidgety)



Changes on term Magnetic Resonance Imaging

Hammersmith Infant Neurological Examination

Journal of *Clinical Medicine*

MDPI

Article

The Pooled Diagnostic Accuracy of Neuroimaging, General Movements, and Neurological Examination for Diagnosing Cerebral Palsy Early in High-Risk Infants: A Case Control Study

Catherine Morgan [1,*], Domenico M. Romeo [2], Olena Chorna [3], Iona Novak [1], Claire Galea [1,4], Sabrina Del Secco [3] and Andrea Guzzetta [3,5]

DMCN Developmental Medicine & Child Neurology

ORIGINAL ARTICLE | Open Access

Predicting neurodevelopmental outcomes in Australian First Nations infants: The transdiagnostic utility of early screening tools

Carly Luke, Katherine A. Benfer, Leeann Mick-Ramsamy, Robert S. Ware, Margot Bosanquet, Natasha Reid, Arend F. Bos, Roslyn N. Boyd, Queensland State-wide LEAP Clinical Group

Official Website

Subscribe for access

https://www.mackeith.co.uk/hammersmith-neurological-examinations/hammersmith-neurological-examinations

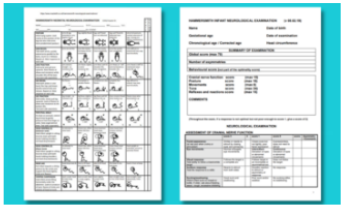
Teaching Videos

Teaching videos show in detail how to perform and score the HNNE and HINE. The HINE is an assessment tool that is often used in concert with other diagnostic tools to form a picture of the neurological condition of an infant. The HINE can be used to gather evidence that can contribute to the diagnosis of neurological abnormality, including (but not limited to) cerebral palsy.

Articles

We have classified the references into nine different groups. If the article is open access the pdf version will be available for downloading from this page. When the article is not open access, a link to the abstract is provided instead. You may find that the full version of most of these articles is accessible through your institution.

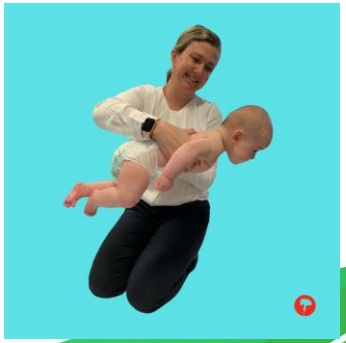
Recording and Scoring Proformas and Guidance Notes (English)



In this section you will find the HNNE and HINE Recording and Scoring Proformas, together with detailed information on how to perform both examinations. The proforma downloads are freely available to all users with or without a subscription.

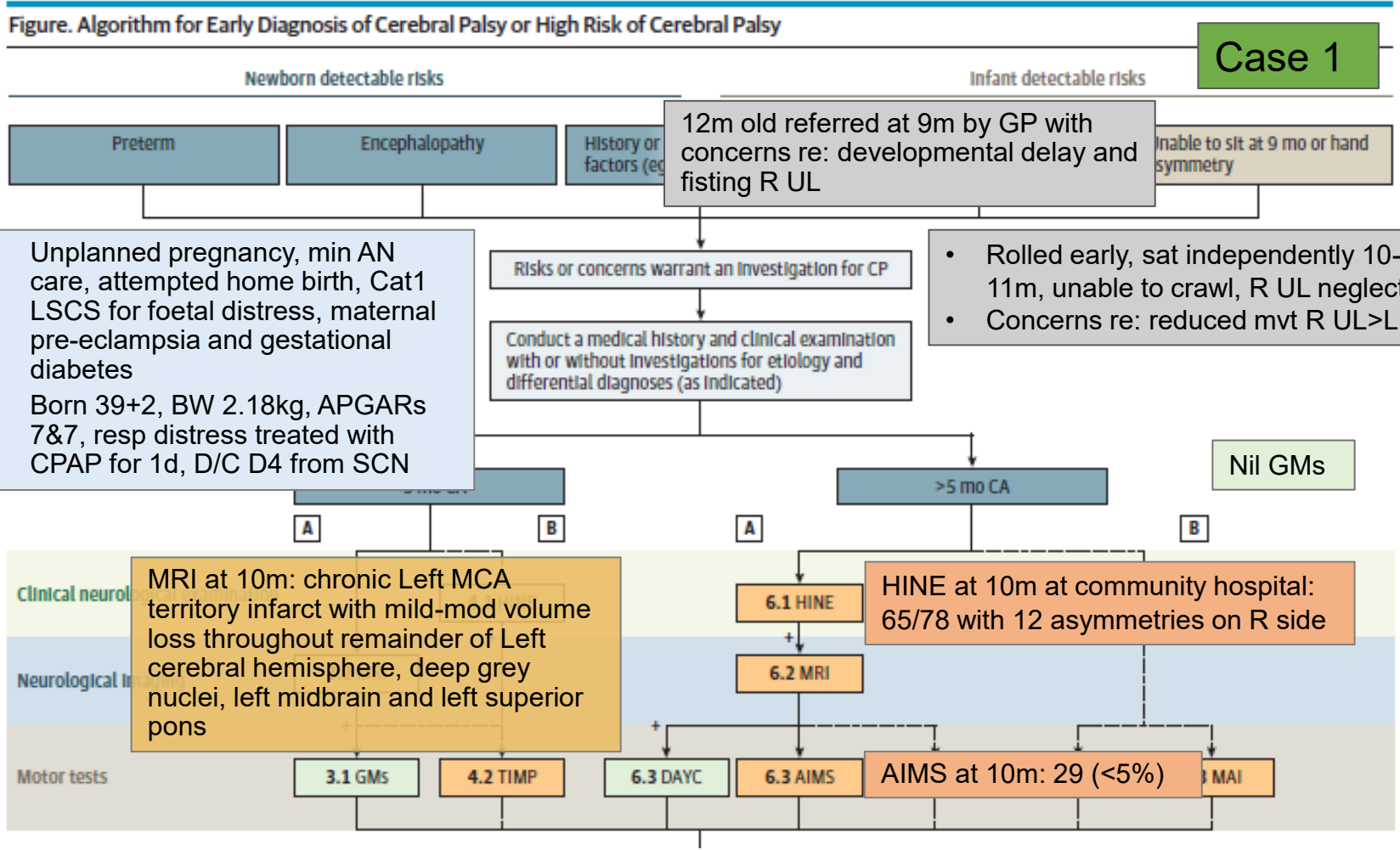
You can download pdf copies of the forms for completion off-line **(new December update for HINE Proforma and Guidance notes now available).**

HINE online training course



Case Studies

Case 1



12m old referred at 9m by GP with concerns re: developmental delay and fisting R UL

- Unplanned pregnancy, min AN care, attempted home birth, Cat1 LSCS for foetal distress, maternal pre-eclampsia and gestational diabetes
- Born 39+2, BW 2.18kg, APGARs 7&7, resp distress treated with CPAP for 1d, D/C D4 from SCN

- Rolled early, sat independently 10-11m, unable to crawl, R UL neglect
- Concerns re: reduced mvt R UL>LL

Nil GMs

MRI at 10m: chronic Left MCA territory infarct with mild-mod volume loss throughout remainder of Left cerebral hemisphere, deep grey nuclei, left midbrain and left superior pons

HINE at 10m at community hospital: 65/78 with 12 asymmetries on R side

AIMS at 10m: 29 (<5%)

Novak et al, 2017

CASE 1: HINE

HINE repeated (12m): *Total Score 61/78 with 18 asymmetries, all R*

- CNF: 13/15
- Posture: 12.5/18
- Movements: 3/6
- Tone: 22/24
- Reflexes and R
- Behaviour: 14

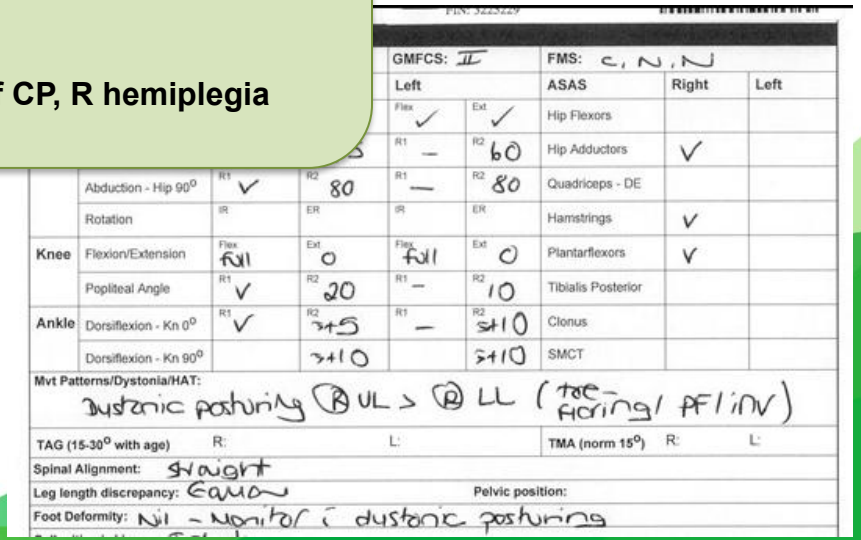
= below cut off score for CP a

- ✓ Clinical history
- ✓ MRI
- X GMs
- ✓ Neurological and Developmental assessments
- ✓ Clinical picture

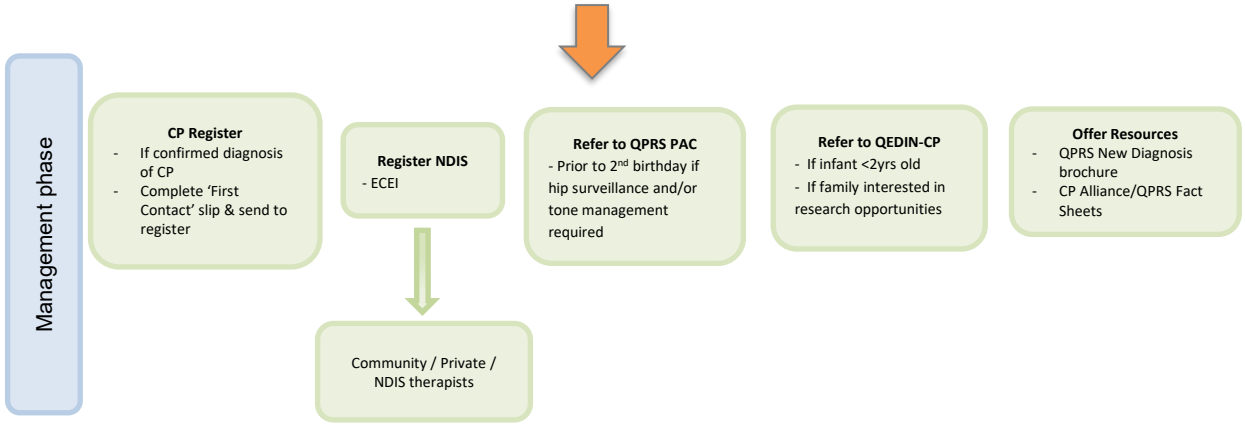
=consistent with a diagnosis of CP, R hemiplegia

AIMS (12m)**:**

- Prone: 16
- Supine: 9
- Sitting: 7
- Standing: 3
- *Total Score:* 35 *Percentile*: <5th%



				GMFCS: II		FMS: C, N, N		
				Left		ASAS	Right	Left
				Flex ✓	Ext ✓	Hip Flexors		
				R1 –	R2 60	Hip Adductors	✓	
	Abduction - Hip 90°	R1 ✓	R2 80	R1 –	R2 80	Quadriceps - DE		
	Rotation	IR	ER	IR	ER	Hamstrings	✓	
Knee	Flexion/Extension	Flex full	Ext 0	Flex full	Ext 0	Plantarflexors	✓	
	Popliteal Angle	R1 ✓	R2 20	R1 –	R2 10	Tibialis Posterior		
Ankle	Dorsiflexion - Kn 0°	R1 ✓	R2 >5	R1 –	R2 >10	Clonus		
	Dorsiflexion - Kn 90°		>10		>10	SMCT		
Mvt Patterns/Dystonia/HAT:								
Dystonic posturing (R) UL > (R) LL (toe flaring/ PF inv)								
TAG (15-30° with age)		R:		L:		TMA (norm 15°)	R:	L:
Spinal Alignment:		Straight						
Leg length discrepancy:		Equal				Pelvic position:		
Foot Deformity:		Nil - Monitor ; dystonic posturing						



- Confirmed diagnosis of Cerebral Palsy, R unilateral, mixed dystonic/spastic
- GMFCS: II (nb 12m), Mini MACS: III FMS: C,N,N
- Education and answer questions
- Resources given: New Diagnosis booklet, fact sheet on HINE
- Feedback to local physio and request to support NDIS if family obtain citizenship
- Referral QEDIN-CP, CP Register
- ORBIT block offered if NDIS delay
- RV QPRS 6 months CPRC clinic
- Hip X-Ray at 2yrs if GMFCS II

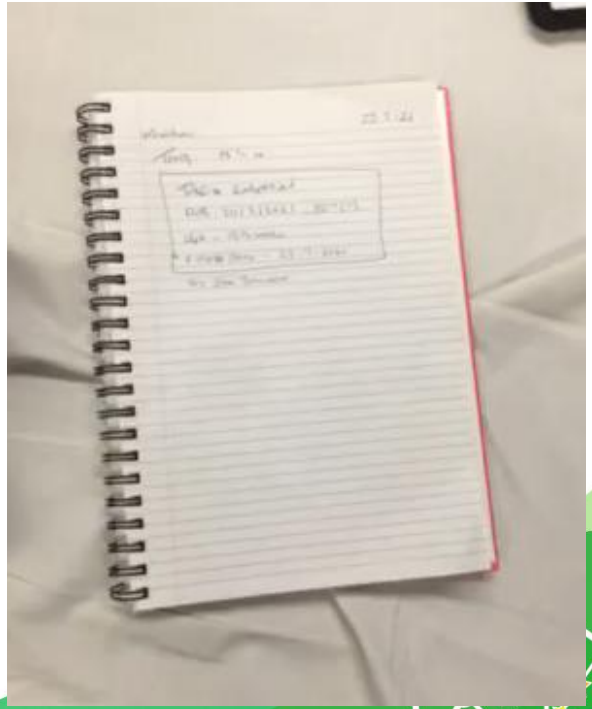
Case 2: Background

Born at 37/40, BW 2340g,
Apgars 6 @1min, 9 @5mins

Prenatal substance exposure –severe alcohol exposure and neonatal abstinence syndrome
Complicated social history
Neuroimaging: not completed

Early assessments:
Fidgety GMA: 12 and 14 wks – normal
MOS-R: non-optimal, trajectory of concern**
12wks= 23
14wks = 21

ASQ-TRAK at 6 months – above cut-off in all domains



**Luke et al. 2024 Early Hum Dev

Case 2: HINE

Completed at 6 months CA

Global Score = 61, 8 asymmetries (5L, 3R)

- Cranial NF: 15/15
- Posture: 8/18
- Movements: 3/6
- Tone: 23/24
- Reflexes and Reactions: 12/15

→ below the 6-month “significant delay” cut-off score (<64)

Interpretation: high likelihood of significant delay and/or CP (Romeo 2022)

Case 2: Outcomes

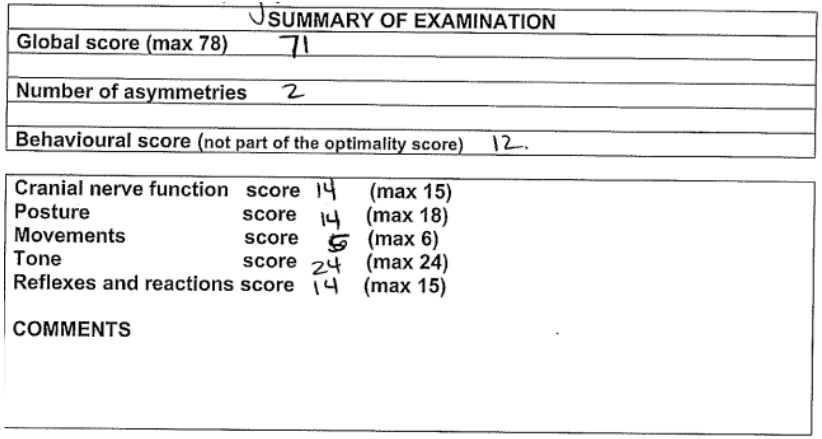
15-month Outcomes

Severely delayed on communication, cognition and fine motor domains (>2SD below mean on standardised Ax)

HINE= 71 (<10th centile), 2 asymmetries

FASD specific facial features = 2

→ Confirmed FASD diagnosis, investigations for autism



SUMMARY OF EXAMINATION		
Global score (max 78)	71	
Number of asymmetries	2	
Behavioural score (not part of the optimality score)	12.	

Cranial nerve function	score	14	(max 15)
Posture	score	14	(max 18)
Movements	score	5	(max 6)
Tone	score	24	(max 24)
Reflexes and reactions	score	14	(max 15)

COMMENTS

Key clinical interpretations:

- Normal Fidgety GMA
- Low MOS-R score but no asymmetry of finger postures/segmental movements
- High number of asymmetries on HINE @ 6m, **but present on both sides**
- Clinical history not typical CP risk factors

Panel Discussion

Before you go…

QEDIN-CP

Queensland Early Detection & Intervention Network - Cerebral Palsy

We want to hear from- Help shape the future of QEDIN!

*Please complete this **2-5 min survey** to help us understand how we can support clinician confidence, knowledge and skill development in early developmental screening*

Website: www.qcprrc.uq.edu.au/qedin-cp Email: qedincp@uq.edu.au Phone: +61 7 3069 7365

Queensland Government | ADVANCE QUEENSLAND | The University Of Queensland AUSTRALIA | AusCP-CTN

Are you a physiotherapist or occupational therapist working with infants born very preterm?

The University of Melbourne

Early developmental intervention for very preterm infants in Australia: Current practice survey

Opportunity to help inform future workforce capabilities and clinical care

We're interested in learning about the experiences of physiotherapists and occupational therapists who work with infants born very preterm (VPT; <32 weeks gestation) and their families in Australia, focusing on care provided from birth to 12 months' corrected age

Who can participate?

Eligible participants:

- ☑ Are an AHPRA registered physio or OT
  AND
- ☑ Have provided care to at least one child born VPT in Australia, in the last 12 months
  AND
- ☑ Have provided care for VPT infants aged from birth to 12 months' corrected age

What is involved?

Participants will complete an online survey which will take approximately 20-30 minutes

You will be asked questions about your professional background, the characteristics of the early developmental intervention that you provide and factors influencing their delivery

Want to know more?

Visit survey link or QR code

https://redcap.link/ri6ibazp

Participation is voluntary and survey responses are anonymous

For more information contact:

Prof. Alicia Spittle aspittle@unimelb.edu.au
Susan Fehring sfehring@student.unimelb.edu.au
9035 5390 or 0410 638 781

University of Melbourne Ethics ID 33710