

Sunny Hill Health Centre at BC Children's Hospital

Gait Assessment in the Community

May 14, 2021

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Objectives

- 1. Outline the physical and functional assessments used to support gait analysis
- Review and practice visual gait analysis to guide clinical decision-making; describe useful tools and methods
- 3. Review the role of Motion Lab and criteria for referral





Elements of Analyzing Gait

- Interview
- Physical assessment
- Community partner input (community therapists, orthotists, physiatrists, pediatricians, orthopedic surgeons, etc.)
- Observational/visual gait analysis





Interview

- Demographic information (age, diagnosis)
- Past history (birth history, milestones)
- Medical history
- Recent x-rays, CT scans, MRI
- Current activity level/extracurricular activities
- Therapy
- Pain











Descriptions of Gross Motor Abilities

GMFCS – E & R Gross Motor Function Classification System Expanded and Revised

GMFCS - E & R

Robert Palisano, Peter Rosenbaum, Doreen Bartlett, Michael Livingston, 2007 CanChild Centre for Childhood Disability Research, McMaster University

GMFCS © Robert Palisano, Peter Rosenbaum, Stephen Walter, Dianne Russell, Ellen Wood, Barbara Galuppi, 1997 CanChild Centre for Childhood Disability Research, McMaster University (Reference: Dev Med Child Neurol 1997;39:214-223)











Ages 6-12

Ages 12-18



GMFCS descriptors copyright O Palisano et al. (1997) Dev Med Child Neurol 39:214-23 CanChild: www.canchild.ca

Illustrations copyright © Kerr Graham, Bill Reid and Adrienne Harvey, The Royal Children's Hospital, Melbourne <u>GMFCS Family Report Questionnaire:</u> <u>Children Aged 2 to 4 Years</u>

Please read the following and mark only one box beside the description that best represents your child's movement abilities.

My child...

Has difficulty controlling head and trunk posture in most positions <u>and</u> uses specially adapted seating to sit comfortably <u>and</u> has to be lifted by another person to move about

Can sit on own when placed on the floor and can move within a room and uses hands for support to maintain sitting balance and usually uses adaptive equipment for sitting and standing and moves by rolling, creeping on stomach or crawling

Can sit on own and walk short distances with a walking aid (such as a walker, reliator, crutches, canes, etc.)

<u>and</u> may need help from an adult for steering and turning when walking with an aid and usually sits on floor in a "W-sitting" position and may need help from an adult to get into sitting and may pull to stand and cruise short distances and prefers to move by creeping and crawling

Can sit on own and usually moves by walking with a walking aid <u>and</u> may have difficulty with sitting balance when using both hands to play <u>and</u> can get in and out of sitting positions on own <u>and</u> can pull to stand and cruise holding onto furniture <u>and</u> can crawl, but prefers to move by walking

Can sit on own and moves by walking without a walking aid and is able to balance in sitting when using both hands to play and can move in and out of sitting and standing positions without help from an adult and prefers to move by walking

Ø Amy Dietrich, Kristen Abercrombie, Jamie Fanning, and Dorean Bartlett, 2007

Available from CanChild Centre for Childhood Disability Research (www.canchild.ca), McMaster University 6MFCS modified with permission from Palisano et al. (1997) Dev Med Child Neurol, 39, 214-223.

GMFCS Family Report Questionnaire

Available for:

- 2-4 years
- 4-6 years
- 6-12 years

www.canchild.ca





Descriptions of Gross Motor Abilities



For children with cerebral palsy aged 4-18 years



Devaloped by the Hugh Williamson Gait Laboratory The Royal Children's Hospital Melbourne, Australia

Part of the Gait CCRE www.rch.org.au/gait



Ratin

Independent on all surfaces:

Does not use any walking aids or need any help from another person when walking over all surfaces including uneven ground, curbs etc. and in a crowded environment,





Uses crutches: Without help from another person.



Rating Uses a walker or frame:



Independent on level surfaces:

Does not use walking aids or need help from another person.* Requires a rail for stairs.

"If uses furniture, walls, fances, shop fronts for support, please use 4 as the appropriate description.







May stand for transfers, may do some stepping supported by another person or using a walker/frame.

Crawling:

Without help from another person.





Child crawls for mobility at home (5m).



N – does not apply: For example child does not complete the distance (500 m).



Rating: select the number Walking distance (from 1-6) which best describes current function 5 metres (yards) 50 metres (yards)

500 metres (yards)





Uses sticks (one or two): Without help from another person.





	ROM	A	MMT	(0-5)	Other	Right	Left
Hip:	Right	Left	Right	Left	Ober Test		
Flexion		L			Ashworth Flex		
Extension					Ashworth Ext		
ABduction					Ashworth ADD		
ADduction					Ely		
External Rot.			Comm	ents:	Thomas Test		
Internal Rot.							
Trend. Test							
	RO/	и	ммт	(0.5)			
Knee:	Right	Left	Right	Left	Other	Right	Left
Elexion	Taight S		- Nigin	Len	Ashworth Elex		
Extension					Ashworth, Ext		
Pop Ang R1			Comr	ents:			
Pop Ang R2				Part Parts			
	RO	M	MMT	(0-5)	Other	Right	Left
Ankle:	Right	Left	Right	Left	Ashworth, Dorsi		
Dorsiflex. (knee 0*)					Ashworth, Plantar		
Dorsiflex. (knee 90*)					Ankle clonus		
Plantarflex					Transmalleolar		
Comments:	Gast sta	nding			Thigh/foot angle		
Reflex comments							
Reflex confinence							
Miscellaneous:						GMFCS	
						FMS !	5
						EMS 5	0
						EMS 50	0
						1110 301	5

Physical Assessment

ROM Muscle strength Muscle tone Rotational profile Leg length Static posture Balance





Selective Motor Control



DEVELOPMENTAL MEDICINE & CHILD NEUROLOGY

ORIGINAL ARTICLE

Selective Control Assessment of the Lower Extremity (SCALE): development, validation, and interrater reliability of a clinical tool for patients with cerebral palsy

EILEEN G FOWLER PHD PT¹ | LORETTA A STAUDT MS PT² | MARCIA B GREENBERG MS PT¹ | WILLIAM L OPPENHEIM MD¹

Developmental medicine and child neurology. 2009;51(8):607-14.





- Inexpensive
- Minimal equipment use
- Very young children
- Better for behavioural/cognitive issues
- Frequent documentation of gait changes
- Baseline to assess need for 3DGA





- Moderate reliability at best
- Inconsistent responses between professionals and over time
- Not ideal for planning complex/multi-level surgery (SEMLS)





Visual Gait Analysis (VGA)

How can we minimize the problems with VGA?

 Frontal and sagittal planes





http://nextlevelstrengthandfitness.com/blogsite/wp-content/uploads/2010/09/Planes7.jpg



- High quality video
 - Lighting/brightness
 - Minimal distractions
 - Clear floor
 - Plain background
 - Quiet







- Low cost mobile video options
 - Tripod (coronal plane)
 - Hand-held Gimbal or selfie stick (sagittal plane)
- Low cost video editing options (mobile apps)
 - Built-in video editor on device
 - Slowmo (Slow Motion Video Analysis)
 - Hudl technique
 - Coach's Eye or Dartfish Express (\$)







- Structured observations
 - Systematic
 - Consistent
 - Top-down approach
 - Rating scales to quantify gait
 - Physician's Rating Scale (PRS)
 - Edinburgh Visual Gait Scale (EVGS)





TABLE 2. Edinbu	rgh Vis	ual Gait Ar	nalysis Int	erval Testi	ng Scale ²⁵						
Movement Sagittal	2	1	0	1	2	Movement Frontal	2	1	0	1	2
FOOT						FOOT					
1 foot clearance	none	reduced	full	n.a	n.a	5 stance position hind foot in load	>15 valgus	6–15 valgus	5–0–5 neutral	6–15 varus	>15 varus
2 initial contact	toe	flat foot	heel	n.a	n.a	6 foot progression angle	>15 ir	6-15 ir	5-0-5 neutral	6–15 er	>15 er
3 heel lift	none	early	normal	delayed	n.a						
4 max dorsiflexion	>10	10-0-9	10-20	21-30 dor	>30						
hind foot in stance	plan	plan/dor	dor		dor						
KNEE						KNEE					
7 terminal swing	>30	15-30	0-15	>0	n.a	10 knee	part	all cap ir	neutral	all	part
÷	flex	flex	flex	hyperext		progression	cap ir			cap er	cap er
						angle mid-stance					
8 peak stance knee	>30	16-30	0-15	1-10	>10						
extension	flex	flex	flex	hyperext	hyperext						
9 peak knee flexion	> 80	65-80	6064	30-59	>30						
in swing	flex	flex	flex	flex	flex						
HIP						HIP					
11 peak hip	>30	16-30	15-0-15	n.a	n.a	13 position	>15	5-15	4-0-9	10-20	>20
extension in stance	flex	flex	flex/ext			in swing	add	add	add/abd	abd	abd
12 peak hip flexion	>75	51-75	30-50	15-29	<15						
in swing	flex	flex	flex	flex	flex						
PELVIS						PELVIS					
14 pelvic rotation midstance	>15 fwd	6–15 fwd	5-0-5 neutral	615 bwd	>15 bwd	15 contra lateral drop					
						in stance	marked	mod	normal	n.a	n.a
TRUNK						TRUNK					
16 peak sagittal	>15	6-15	5-0-5	6-15	>15	17 max lateral					
position in stance	fwd	fwd	neutral	bwd	bwd	shift in stance	marked	mod	neutral	n.a	n.a
TOTAL						TOTAL					

Score 2 means marked deviation, score 1 is moderate deviation, score 0 is normal range.

n.a, not available; plan, plantarflexion; dor, dorsiflexion; flex, flexion; hyperext, hyperextension; fwd, forward rotation; bwd, backward rotation; ir, internal rotation; er, external rotation; part cap, only a part of the knee cap is visible; all cap, whole knee cap is visible; add, adduction; add, abduction; lat, lateral; mod, moderate.



Matthuis KGB. J Pediatr Orthop. 2005;25:268-272; Rathinam et al. Observational gait assessment tools in paediatrics-- a systematic review. Gait Posture. 2014;40(2):279-85.



- Ensure you can see all joints
 - Shorts and t-shirt
 - Anatomical markings
- Phases of gait
- Understand typical gait
- Gait terminology





Phases of Gait



Perry J. Gait analysis: Normal and pathological function. 1992. Thorofare, NJ: Slack Incorporated.





Stance Phase



Swing Phase







Prerequisites of Typical Gait

- Stability in stance
- Sufficient foot clearance during swing
- Appropriate swing phase pre-positioning of foot
- Adequate step length
- Energy conservation

Gage JR. The Treatment of Gait Problems in Cerebral Palsy. 2004; MacKeith Press: London, UK





Gait Terminology

- Trendelenburg gait/compensated
 Trendelenburg
- Early heel rise
- Foot rockers
 - First/heel rocker
 - Second/ankle rocker
 - Third/forefoot rocker





Gait Terminology







Case Studies

- Cerebral Palsy
 - Diplegia
 - Hemiplegia
- Meningomyelocele





Gait Patterns in CP

Common Gait Patterns: Spastic Diplegia



C C

Rodda J, Graham HK. Classification of gait patterns in spastic hemiplegia and spastic diplegia: a basis for a management algorithm. Eur J Neurol 2001; 8(s5): 98-108

BC Children's

Hospital Provincial Health Services Authority Sunny Hill Health Centre

Case Study: CP Diplegia

Relevant Surgeries and Dates (past and planned):	SDR 2016 bilateral VDRO - 6 months following SDR	
Appointment Info:	bilateral ESR AFOs just received	

Current Activities	
School Grade:	7
Physical Activities:	game ready at school activities in the gym
Endurance:	.5 hour Are Falls a Problem? yes
	How many times per day? once in awhile, running
Wheelchair use?	No Mobility Aids? No
Therapy:	
Bracing Orthosis:	ESR Side Both Prosthesis:
Orthotist	Hodgsons Age of Brace 3 weeks
Question:	What is the degree of jump/crouch gait? What is the impact of his rotational profile on his gait?
Marker Loss?	No
Birth History:	30 weeks GA; twin A; MRI showed periventricular leukomalacia



Case Study: CP Diplegia

Interviev	N	A	ctivities		Exam	F	rocessir	ıg	V3D	Files		Stats
Hin	F	ROM	MMT	(0-5)	Other							
inp.	Right	Left	Right	Left		Right	Left	Com	ments:			
Flexion	115	110	5	5	Ober Test	Neg	Neg					
Extension	0	0	4	4	Ashworth Flex	0	0					
ABduction	10/25	10/20	4	4	Ashworth Ext	0	0					
ADduction	15	15	4	4	Ashworth ADD	1	1					
External Rot.	20	15			Ely	/80	-/65					
Internal Rot.	65	55			Thomas Test	Neg	Neg					
					SMC	2	2					
	ROI	и	ммт	(0-5)	Other							
Knee:	Right	Left	Right	Left		Right	Left	Com	ments:			
Flexion	140	140	4	4	Ashworth, Flex	1	1+					
Extension	-10	-15	4+	4+	Ashworth, Ext	0	0					
Pop Ang R1	-90	-90			SMC	2	2					
Pop Ang R2	-70	-70										
Anklas	DO	И	A // A // T	(0.5)	Othor							
AIIKIC.	Right	" Left	Right	Left	ouler	Right	Left					
Dorsiflex. (knee 0°)	-5/5	-10/0			Ashworth, Dorsi	0	0	:	SMC Ankle	1	1	
Dorsiflex (knee 90°)	5/10	5/10	4-	4-	Ashworth, Plantar	1	1+		SMC STJ	1	1	
Plantarflex	40	50	4	4	Thigh/foot angle	10 ex	10 ex		SMC Toes	1	1	
Midfoot					Gast standing	5	5	Com	ments:			
					Transmalleolar	15 ex	15 ex					
					Ankle clonus	0	0					
Miscellaneo	us:						_		-			
uses raili	ng on sta	airs					_	GMFCS	2			
LLD: right 1	1.5 cm lo	nger						FMS 5	5			
								FMS 50	6			
							F	MS 500	6			

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Cerebral Palsy, Diplegia

- Frontal
- Sagittal
- Frontal, <u>AFOs</u>
- Sagittal, <u>AFOs</u>





Gait Patterns in CP

Common Gait Patterns: Spastic Hemiplegia



Roddy J, Graham HK. Classification of gait patterns in spastic hemiplegia and spastic diplegia: a basis for a management algorithm. Eur J Neurol 2001; 8(s5): 98-108



Case Study: CP Hemiplegia

1º Diagnosis: 2º Diagnosis :	Cerebral Palsy, Hemiplegic	343.101	G80.2	Height:	117.3 X-Ray?	cm Weight	21.2	kg		
Relevant Surgeries				cast mp	A hay:	Dec	020			
and Dates (past and planned):	Strabismus surgery bilaterally (2016)									
Appointment Info:	right articulating AFO in proce	ess coordin	ated							
Comments:	Comments: right equinus/? fixed hip surveillance program - last seen Dec 2020 Question: Baseline assessment.									
Question:										
Is there pain?	No If yes Where?									
Status	Coordinate with Ortho Appt									





Case Study: CP Hemiplegia

Current Activities								
School Grade:	1							
Physical Activities:	Running, P wants to ti	Running, PE 3x/wk - participates fully except in last 15 minutes he rests, wants to try soccer this spring/summer						
Endurance:	2 blocks	Are	Falls a Probl	em?	Yes			
		How ma	ny times per (day?	Multiple times per day			
Wheelchair use?	No	Io Mobility Aids? No						
Therapy:								
Bracing Orthosis:	Articulated	d AFO	Side	RT	Prosthesis:			
Orthotist	Kintec Foo	tlabs	Age of Brace	4 mo	nths			
Question:	Baseline a	assessment.						
Marker Loss?	No							
Birth History:	Delivery at Respirator Problems Walked at Talked ear Fine and g	t 31 weeks at 4 lb ry complication at with apnea in the t 13 months rly, no language o gross motor defici	s t birth requiri e newborn pe or cognitive is ts on right sid	ng prol riod an sues de sinc	onged hospitalization d difficulty feeding e birth			





Case Study: CP Hemiplegia

Hip:	Right	OM Left	MMT Right	(0-5)	Other	Right	le	ft	Comm	ients:			
El avian	110	120	A	5	Ober Test	Nez	Nee						
Flexion	0	120	4	-	Ober Test	Neg	Neg						
Extension		0	4	2	Ashworth Flex	U	0						
ABduction	35	40	4	5	Ashworth Ext	0	0						
ADduction	20	20	5	5	Ashworth ADD	0	0						
External Rot.	30	30			Ely	-/150	-/150)					
Internal Rot.	65	60			Thomas Test	Neg	Neg						
					SMC	2	2						
	RON	N	MMT	(0-5)	Other				_				
Knee:	Right	Left	Right	Left		Right	Le	ft	Comm	ients:			
Flexion	150	150	4	5	Ashworth, Flex	1	0						
Extension	0	0	5	5	Ashworth, Ext	0	0						
Pop Ang R1	-50	-			SMC	2	2						
Pop Ang R2	-45	-40											
Ankle:	RON	л	MMT	(0-5)	Other								
	Pight	Left	Right	Left		Right	Le	ft					
Dorsiflex. (knee 0°)	-30/	15	\frown		Ashworth, Dorsi	0	0		S	MC Ankle	1	2	_
Dorsiflex. (knee 90°)	-25/	20	3+	4	Ashworth, Plantar	1+	0			SMC STJ	2	2	_
Plantarflex	50	50	3+	5	Thigh/foot angle	0	10 e	x		SIVIC TOES	1	2	
Midfoot			\bigcirc		Gast standing	3	10		Comr	nents:			
					Transmalleolar	10 ex	25 e)	x					
					Ankle clonus	3	0						
Miscellaneou	IS:									r			
Stairs: sha	ky, uses	railing							SMFCS	2			
AFO: wears	s two ho	urs per o	lay at scl	nool, co	mplains of pain ove	r lateral			FMS 5	5			
malleolus	, minima	al paddii 1 cm sho	ng, no bl	isters si	nce new AFO in Dec	2020		F	MS 50	5			
LLD. KI TEg	approx	i chi she	i cei					FN	/IS 500	5			









Cerebral Palsy, Hemiplegia

- Frontal
- Sagittal
- Frontal, <u>AFO</u>
- Sagittal, <u>AFO</u>





Pathological Gait

Levels of Gait Abnormalities:

 Primary: Loss of selective motor control Difficulties with balance Abnormal muscle tone
 Secondary: Muscle contractures Abnormal bone growth
 Tertiary: Coping mechanisms for 1° and 2°



Gage JR. The Treatment of Gait Problems in Cerebral Palsy. 2004; MacKeith Press: London, UK

Hip Pathology in Cerebral Palsy (CP)

- Muscle weakness
 - Extensors/Abductors
- Spasticity and contractures
 - Flexors/Adductors
- Mechanical dysfunction
 - Short lever arm
 - Malrotated lever arm
 - Unstable fulcrum



Impaired motor control



Types of Lever Arm Dysfunction

Malrotated lever arm



Unstable fulcrum





Knee Pathology in CP

- Lever arm dysfunction
- Inappropriate muscle moments





Types of Lever Arm Dysfunction

Positional lever arm dysfunction





Figure 1 - Crouch Gait: increase knee flexion during stance phase and the external flexion moment





Ankle Pathology in CP

- Inappropriate muscle moment
- Lever arm dysfunction
 - Flexible lever arm
 - Malpositioned lever arm





Types of Lever Arm Dysfunction

Short lever arm





Flexible lever arm





Case Study: Meningomyelocele

1º Diagnosis:	Lipomyelomeningocele	756.1	Height: 123.2 c	m Weight 22.4 kg				
2º Diagnosis :			Last Hip X-Ray?					
Relevant Surgeries and Dates (past and planned): Appointment Info:	- March 22, 2018: tibial derotat posteromedial release on rig - April 4, 2019 - Botox injection - Lipomyelomeningocele - det	tion osteotomy an ht; tibialis posteri s into tibialis ant ethering done at 1	d plantar fascia release bi or lengthening on left erior Lyear of age	laterally;				
Comments:	(
Question:	Does she have true or apparent knee valgus, secondary to knee flexion? Would ground reaction AFOs help knee position? Compare ankle foot orthoses (AFOs) versus knee ankle foot orthoses							
Is there pain? Status	Yes If yes Where? Coordinate with Trip to Van	when using KA	FOs right hip pain					





Case Study: Meningomyelocele

Current Activities								
School Grade:	2							
Physical Activities:	skating, skiing	skating, skiing, swimming in summer, playing outside						
Endurance:	.5 hour	.5 hour Are Falls a Problem? yes						
	How many times per day? occasionally							
Wheelchair use?	uses e- Mobility Aids? No							
Therapy:	school PT, strengthening exercises for team to do re: recess and gym							
Bracing Orthosis:	Fixed AFO		Side	Both	Prosthesis:			
	Fixed KAFO		Ì	Both				
Orthotist	Orthodynamics	Age of	f Brace					
Question:	Does she have Would ground orthoses (AFOs	true or apparent i reaction AFOs hel s) versus knee ank	knee val p knee p le foot c	gus, see osition orthoses	condary to knee flexion? ? Compare ankle foot s (KAFOs).			
Marker Loss?	No)						
Birth History:	casted for new stand up elect drive to school	AFOs ric scooter for long l in winter	er dista	nces in	summer			

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Case Study: Meningomyelocele









Meningomyelocele

- Frontal
- Sagittal
- Frontal, <u>AFOs</u>
- Sagittal, <u>AFOs</u>





Role of the Motion Lab

- Standardized
- 3-Dimensional
- Detailed objective evaluation
- Enables direct comparison/follow-up





- Requires extensive equipment
- Significant training/experience required for data interpretation
- Resources
- Not always available!







Elements of Computerized Gait Analysis

- Kinematics
- Kinetics
- Muscle Activation
- Pedobarography

















Measuring Kinematics

Position in space

- Joint angles
- Displacement
- Velocities
- Accelerations





Pelvis Kinematics







Hip Kinematics



Normal Function of the Hip:

- Power generation for movement
- Junction between lower extremities & trunk
- Minimizes vertical oscillation of the centre of mass





Knee Kinematics



Normal Function of the Knee:

- Shock absorption in loading response
- Energy consumption
- Foot clearance during swing





Ankle Kinematics



Requirements for Normal Function of the Ankle:

- Foot functions as stable platform
- Appropriate power generation/absorption of muscles
- Knee and ankle are in plane of progression
- Ankle has adequate ROM





Measuring Kinetics





- Ground Reaction Forces (GRF)
- Joint Moments
- Joint Powers
- Muscle and Ligament Forces







Muscle Activation: Electromyography



Pedobarography:

Plantar pressure distribution of the foot







Recommendations

- Data are reviewed
- Each clinician contributes to analysis according to their area of expertise
- Recommendations emerge regarding
 - Orthoses
 - Therapeutic
 - Surgical





Criteria for Referral

- Specific question!
- PT, Orthopedic Surgeon, Physiatrist, Pediatrician, Orthotist or Prosthetist, GP
- 5 years of age
- Able to tolerate sticker application and removal; 2-3 hour assessment
- Information re: orthoses (past/present)





Motion Lab Referral



http://www.bcchildrens.ca/our-services/sunny-hill-health-centre/our-services/gait-assessment







The Motion Lab Requisition for Gait Analysis at Sunny Hill Health Centre

Patient Criteria: 1. Minimum age is 5 years Motion Lab Use Only 2. Must be able to cooperate for a minimum of 2 hours Urgent Routine 3. Must be capable of ambulation Date Rec'd							
Patient's Name (first last) BCCH Medical Record # Diagnosis Patient's Address City Patient's Phone #	Personal Health Number Parents Names Province Posta Date of Birth	al Code					
Referrer: Referrer's Phone: Previous Gait Studies: Yes No Seen at Sunny Hill before? Relevant Surgeries and Dates (past and planned): Type of Orthosis or Bracing							
Referral Request What question would with the procession of the procession	ld you like answered by this referral?						
Is an interpreter required? Who is the Physical Therapist for this child?	Yes No						
Comments	Data	of Pequet					





The Motion Lab is located at Sunny Hill Health Centre at BC Children's Hospital

4500 Oak St, Vancouver, B.C., V6H 3N1 Motion Lab Booking Telephone (604) 453-8318 Requisition Fax Number (604) 453 8321

Revision Date: 10/15/2020



Motion Lab Team



M.um

