Bone & Joint Open

Supplementary Material

Table i. Systematic review search strategy for PubMed, SCOPUS and Web of Science. Only papers published after 01/01/11 were searched. All searches were run on 05/11/21.

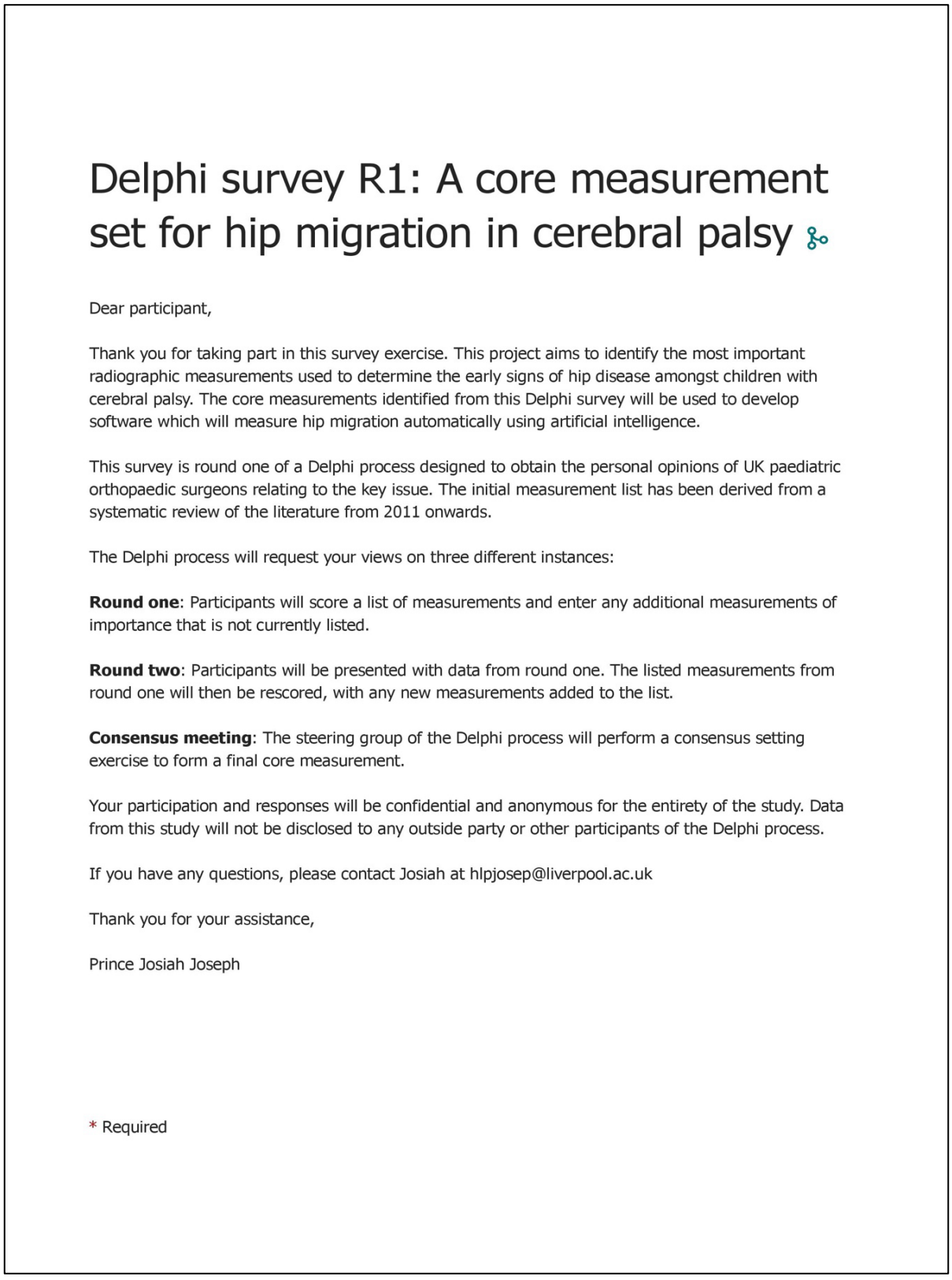
Appendix 1			
Database	**Number**	**Query**	**Notes**
PubMed	#1	Cerebral pals*[tiab]	
	#2	Cerebral palsy[Mesh]	
	#3	Little's disease[tiab] OR Little Disease[tiab] OR Spastic Diplegi*[tiab]	
	#4	Little's disease[Mesh] OR Little Disease[Mesh] OR Spastic Diplegia[Mesh]	
	#5	#1 OR #2 OR #3 OR #4	Cerebral Palsy
	#6	Paediatric*[tiab] OR pediatric*[tiab] OR neonat*[tiab] OR infant*[tiab] OR child*[tiab] OR adolescen*[tiab] OR teen*[tiab] OR young adult*[tiab]	
	#7	Pediatrics[Mesh] OR Infant[Mesh] OR Child[Mesh] OR Adolescent[Mesh:NoExp] OR Young Adult[Mesh:NoExp]	
	#8	#6 OR #7	Paediatrics

	#9	hip[tiab] OR pelv*[tiab] OR acetab*[tiab] OR cotyloid[tiab] OR coxa*[tiab] OR ischi*[tiab]	
	#10	hip[Mesh] OR pelvic bones[Mesh] OR acetabulum[Mesh] OR acetabula[Mesh] OR acetabulas[Mesh] OR coxa[Mesh] OR coxas[Mesh] OR ischium[Mesh]	
	#11	#9 OR #10	Hip
	#12	radiograph*[tiab] OR radiol*[tiab] OR x-ray*[tiab] OR x ray*[tiab] OR xray*[tiab] OR X-Radiation*[tiab] OR XRadiation*[tiab] OR X Radiation*[tiab] OR roentgen ray*[tiab]	
	#13	radiography[Mesh] OR radiology[Mesh] OR x-ray[Mesh] OR x ray[Mesh] OR xray[Mesh] OR X-Radiation[Mesh] OR X Radiation[Mesh] OR roentgen ray[Mesh]	
	#14	#12 OR #13	X-ray
PubMed	#15	#5 AND #8 AND #11 AND #14	Cerebral Palsy AND Paediatrics AND Hip AND X-ray
SCOPUS	#1	TITLE-ABS-KEY("Cerebral pals*")	
	#2	TITLE-ABS-KEY("Little* disease" OR "Spastic Diplegi*")	

	#3	#1 OR #2	Cerebral Palsy
	#4	TITLE-ABS-KEY(Paediatric* OR pediatric* OR neonat* OR infant* OR child* OR adolescen* OR teen* OR "young adult*")	
	#5	TITLE-ABS-KEY(hip OR pelvi* OR acetabul* OR cotyloid OR coxa* OR ischi*)	
	#6	TITLE-ABS-KEY(radiograph* OR radiol* OR "x-ray*" OR "x ray*" OR xray* OR "X-Radiation*" OR XRadiation* OR "X Radiation*" OR "roentgen ray*")	
	#7	#3 AND #4 AND #5 AND #6	Cerebral Palsy AND Paediatrics AND Hip AND X-ray
Web of Science	#1	TS=("Cerebral pals*")	
	#2	TS=("Little* disease" OR "Spastic Diplegi*")	
	#3	#1 OR #2	Cerebral Palsy
	#4	TS=(Paediatric* OR pediatric* OR neonat* OR infant* OR child* OR adolescen* OR teen* OR "young adult*")	
	#5	TS=(hip OR pelvi* OR acetabul* OR cotyloid OR coxa* OR ischi*)	
	#6	TS=(radiograph* OR radiol* OR "x-ray*" OR "x ray*" OR xray* OR "X-Radiation*" OR XRadiation* OR "X Radiation*" OR "roentgen ray*")	

	#7	#3 AND #4 AND #5 AND #6	Cerebral Palsy AND Paediatrics AND Hip AND X-ray

Figure a. Delphi surveys. Pelvic obliquity, which was included in round one, was excluded from further rounds as the steering committee determined that it did not directly measure hip disease in CP and only considered the acceptability of the radiograph. It has also been retrospectively excluded from the systematic review. All questionnaires were made using Microsoft forms.



Delphi survey R1: A core measurement set for hip migration in cerebral palsy

Dear participant,

Thank you for taking part in this survey exercise. This project aims to identify the most important radiographic measurements used to determine the early signs of hip disease amongst children with cerebral palsy. The core measurements identified from this Delphi survey will be used to develop software which will measure hip migration automatically using artificial intelligence.

This survey is round one of a Delphi process designed to obtain the personal opinions of UK paediatric orthopaedic surgeons relating to the key issue. The initial measurement list has been derived from a systematic review of the literature from 2011 onwards.

The Delphi process will request your views on three different instances:

Round one: Participants will score a list of measurements and enter any additional measurements of importance that is not currently listed.

Round two: Participants will be presented with data from round one. The listed measurements from round one will then be rescored, with any new measurements added to the list.

Consensus meeting: The steering group of the Delphi process will perform a consensus setting exercise to form a final core measurement.

Your participation and responses will be confidential and anonymous for the entirety of the study. Data from this study will not be disclosed to any outside party or other participants of the Delphi process.

If you have any questions, please contact Josiah at hlpjosep@liverpool.ac.uk

Thank you for your assistance,

Prince Josiah Joseph

* Required

Scoring of core measurement set

Below is an initial list of measurements that have been identified from a systematic review looking at the radiographic measurements of hips in children with cerebral palsy. Please score all the measurements to the best of your knowledge.

A 9 point Likert scale will be used to determine the importance of each measurement.
Scores of 1–3 will be considered 'not important'.
Scores of 4–6 will be considered 'important but not critical'.
Scores of 7–9 will be considered 'critically important'.

5. Reimer's migration percentage (1='not important' to 9='critically important') *

1 2 3 4 5 6 7 8 9

6. Pelvic obliquity (1='not important' to 9='critically important') *

1 2 3 4 5 6 7 8 9

7. Femoral head-shaft angle HSA (1='not important' to 9='critically important') *

1 2 3 4 5 6 7 8 9

8. Femoral neck-shaft angle (1='not important' to 9='critically important') *

1 2 3 4 5 6 7 8 9

9. Mose hip ratio (1='not important' to 9='critically important') *

1 2 3 4 5 6 7 8 9

16. Hilgenreiner epiphyseal angle (1='not important' to 9='critically important') *

1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

17. Pelvic femoral angle (1='not important' to 9='critically important') *

1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

18. Pelvic adjusted migration percentage (1='not important' to 9='critically important') *

1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

19. Medialization index (1='not important' to 9='critically important') *

1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

20. Do you want to add any additional measurements to this list? *

- ○ Yes
- ○ No

Additional measurements (optional)

Below is a free text option for you to add any additional measurements that are used on hip radiographs in children with cerebral palsy, that has not been included in the list of measurements from the previous section

21. Additional measurements:

Registration

Please complete the questions below.

1

Full name: *

2

Email address: *

3

Hospital: *

4

Role: *

Scoring of measurements with results from Round 1

Below is the list of measurements along with the results from the 1st round of the Delphi process.

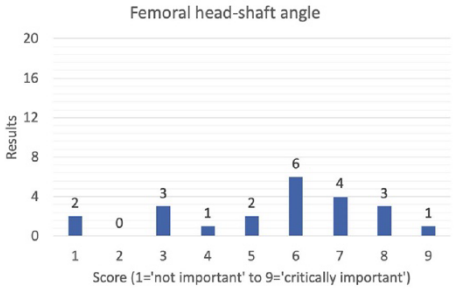
A total of 22 participants took part in the previous round.

Please score all the measurements to the best of your knowledge after reviewing the results of Round 1.

A 9 point Likert scale will be used to determine the importance of each measurement.
Scores of 1–3 will be considered 'not important'.
Scores of 4–6 will be considered 'important but not critical'.
Scores of 7–9 will be considered 'critically important'.

7

Femoral head-shaft angle HSA (1='not important' to 9='critically important') *

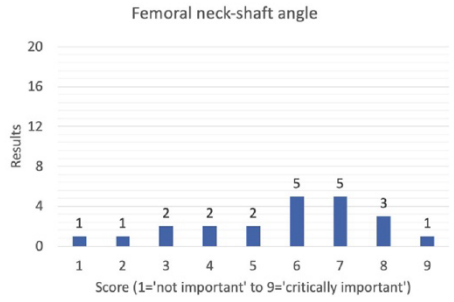


1 2 3 4 5 6 7 8 9

○ ○ ○ ○ ○ ○ ○ ○ ○

8

Femoral neck-shaft angle (1='not important' to 9='critically important') *

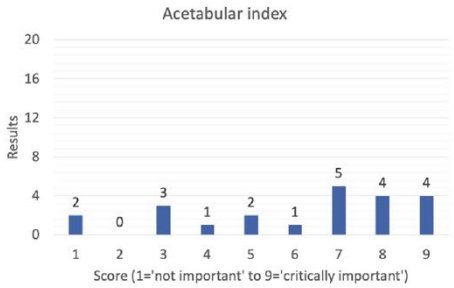


1 2 3 4 5 6 7 8 9

○ ○ ○ ○ ○ ○ ○ ○ ○

9

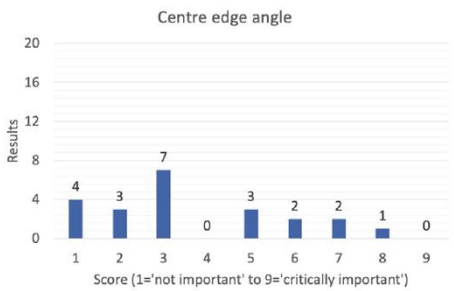
Acetabular index (1='not important' to 9='critically important') *



1 2 3 4 5 6 7 8 9

10

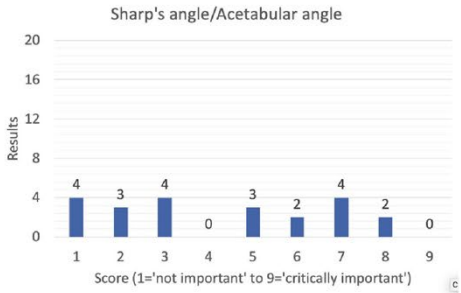
Centre edge angle (1='not important' to 9='critically important') *



1 2 3 4 5 6 7 8 9

11

Sharp's angle or Acetabular angle (1='not important' to 9='critically important') *



1 2 3 4 5 6 7 8 9

18

Medialization index (1='not important' to 9='critically important') *

1 2 3 4 5 6 7 8 9

○ ○ ○ ○ ○ ○ ○ ○ ○

Scoring of new measurements

Below is a list a new measurements that have been suggested by partcipants from round one of the Delphi process.

Please score all the measurements to the best of your knowledge.

A 9 point Likert scale will be used to determine the importance of each measurement.
Scores of 1–3 will be considered 'not important'.
Scores of 4–6 will be considered 'important but not critical'.
Scores of 7–9 will be considered 'critically important'.

19

Sourcil (Tönnis) angle (1='not important' to 9='critically important') *

1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

20

Femoral head shape/congruency (1='not important' to 9='critically important') *

1	2	3	4	5	6	7	8	9
○	○	○	○	○	○	○	○	○

Table ii: Studies that were not accessible.

Title	Author	Year	Journal
Early Bony Hip Reconstructive Surgery for Hip Subluxation in Children With Severe Cerebral Palsy	Bean, B. K. and Baird, G. O. and Caskey, P. M. and Bronson, W. B. and McMulkin, M. L. and Tompkins, B. J.	2020	Orthopedics
Evaluation of adductor myotomy versus adductor transfer to ischiadic tuber in the treatment of spastic hip in cerebral palsy	Andrzej Borowski, Ewa Pogonowicz, Rafał Plebański, Marek Synder, Andrzej Grzegorzewski	2011	Ortopedia Traumatologia Rehabilitacja
Two-stage surgery in the treatment of spastic hip dislocation--comparison between early and late results of open reduction and derotation-varus femoral osteotomy combined with Dega pelvic osteotomy preceded by soft tissue release	Marek Jóźwiak and Aleksander Koch	2011	Ortopedia, Traumatologia Rehabilitacja
Soft tissue, varus derotation femoral and pelvic surgery in cerebral palsy children: A mid-term outcome study	Panou, A. and Testa, G. and Peccati, A. and Tsibidakis, H. and Portinaro, N. M.		Minerva Ortopedicae Traumatologica
The effect of obturator nerve block on hip lateralization in low functioning children with spastic cerebral palsy	Park, E. S. and Rha, D. W. and Lee, W. C. and Sim, E. G.	2014	Yonsei Med J
Outcome of Femoral Varus Derotational Osteotomy for the Spastic Hip Displacement: Implication for the Indication of Concomitant Pelvic Osteotomy	Park, H. and Abdel-Baki, S. W. and Park, K. B. and Park, B. K. and Rhee, I. and Hong, S. P. and Kim, H. W.	2020	Journal of Clinical Medicine

Table iii: Studies included in the systematic review.

Study ID	Title	Author (Year)	Journal	Location
1	Hip pain in adolescents with cerebral palsy: a population-based longitudinal study	Larsen (2021)	Dev Med Child Neurol	Norway
2	Remodelling of femoral head deformity after hip reconstructive surgery in patients with cerebral palsy	Min (2021)	Bone Joint J	South Korea
3	Failure of Hip Reconstruction in Children With Cerebral Palsy: What Are the Risk Factors?	Minaie (2021)	J Pediatr Orthop	USA
4	Combined pelvic and femoral reconstruction in children with cerebral palsy	Alassaf (2018)	J Int Med Res	Canada
5	Recurrence of hip instability after reconstructive surgery in patients with cerebral palsy	Bayusentono (2014)	J Bone Joint Surg Am	South Korea
6	Hip-joint congruity after Dega osteotomy in patients with cerebral palsy: long-term results	Braatz (2016)	Int Orthop	Germany
7	Hip displacement in children with cerebra palsy in Scotland: a total population study	Bugler (2018)	Journal of Childrens Orthopaedics	Scotland (UK)
8	Results and complications of percutaneous pelvic osteotomy and intertrochanteric varus shortening osteotomy in 54 consecutively operated GMFCS level IV and V cerebral palsy patients	Canavese (2017)	Eur J Orthop Surg Traumatol	France and Switzerland
9	Hip Development After Selective Dorsal Rhizotomy in Patients with Cerebral Palsy	Chan (2013)	Journal of Orthopaedics, Trauma and Rehabilitation	China
10	Outcomes of Isolated Varus Derotational Osteotomy in Children With Cerebral Palsy Hip Dysplasia and Predictors of Resubluxation	Chang (2018)	J Pediatr Orthop	USA

11	Prevalence and predictive factors of hip displacement in children with cerebral palsy at paediatric institute, Kuala Lumpur hospital	Ching (2017)	Neurology Asia	Malaysia
12	Determinants of Hip and Femoral Deformities in Children With Spastic Cerebral Palsy	Cho (2018)	Ann Rehabil Med	South Korea
13	Is head shaft angle a valuable continuous risk factor for hip migration in cerebral palsy?	Chougule (2016)	Journal of Children's Orthopaedics	England (UK)
14	The Impact of Spinal Fusion on Hip Displacement in Cerebral Palsy	Cobanoglu (2020)	Indian J Orthop	USA
15	Soft tissue surgery as an initial treatment for hip displacement in spastic cerebral palsy	Silva (2020)	Sicot-J	Brazil
16	Prevalence of hip dislocation among children with cerebral palsy in regions with and without a surveillance programme: a cross sectional study in Sweden and Norway	Elkamil (2011)	BMC Musculoskelet Disord	Sweden and Norway
17	Soft tissue release of the spastic hip by psoas-rectus transfer and adductor tenotomy for long-term functional improvement and prevention of hip dislocation	Heimkes (2011)	Journal of Pediatric Orthopaedics Part B	Germany
18	Head-shaft angle is a risk factor for hip displacement in children with cerebral palsy	Hermanson (2015a)	Acta Orthop	Sweden
19	Surgical management of hip subluxation and dislocation in children with cerebral palsy: isolated VDRO or combined surgery?	Huh (2011)	J Pediatr Orthop	USA
20	Five-year outcome of state-wide hip surveillance of children and adolescents with cerebral palsy	Kentish (2011)	Journal of Pediatric Rehabilitation Medicine	Austrailia

21	Hip displacement in relation to age and gross motor function in children with cerebral palsy	Larnert (2014)	Journal of Children's Orthopaedics	Sweden
22	The prognostic value of the head-shaft angle on hip displacement in children with cerebral palsy	List (2015a)	Journal of Children's Orthopaedics	Netherlands
23	Parameters of radiographic coxometry in reconstructive operations on the hip joint as part of multilevel surgical interventions in children with cerebral palsy	Tomov (2019)	Genij Ortopedii	Russia
24	Use of iliac crest allograft for Dega pelvic osteotomy in patients with cerebral palsy	Sung (2018a)	BMC Musculoskelet Disord	South Korea
25	Hip pain is more frequent in severe hip displacement: a population-based study of 77 children with cerebral palsy	Ramstad (2016)	J Pediatr Orthop B	Norway
26	Hip displacement and dislocation in a total population of children with cerebral palsy in Scotland	Wordie (2020)	Bone Joint J	Scotland (UK)
27	The Femoral Head-Shaft Angle Is Not a Predictor of Hip Displacement in Children Under 5 Years With Cerebral Palsy: A Population-based Study of Children at GMFCS Levels III-V	Terjesen (2021)	J Pediatr Orthop	Norway
28	Fate of stable hips after prophylactic femoral varization osteotomy in patients with cerebral palsy	Sung (2018b)	BMC Musculoskelet Disord	South Korea
29	Avascular necrosis as a complication of the treatment of dislocation of the hip in children with cerebral palsy	Koch (2015)	Bone Joint J	Poland
30	The natural history of hip development in cerebral palsy	Terjesen (2012)	Dev Med Child Neurol	Norway
31	Hip displacement in children with cerebral palsy	Wordie (2021)	Bone Joint J	Scotland (UK)

32	Acetabular and femoral remodeling after varus derotational osteotomy in cerebral palsy: The effect of age and Gross Motor Function Classification Level	Shore (2016)	Journal of Pediatric Orthopaedics Part B	USA
33	Severe hip displacement reduces health-related quality of life in children with cerebral palsy	Ramstad (2017)	Acta Orthop	Norway
34	Patterns of hip migration in non-ambulant children with cerebral palsy: A prospective cohort study	Poirot (2020)	Annals of Physical and Rehabilitation Medicine	France
35	Outcome of Femoral Varus Derotational Osteotomy for the Spastic Hip Displacement: Implication for the Indication of Concomitant Pelvic Osteotomy	Park (2020)	Journal of Clinical Medicine	South Korea
36	Incidence and risk factors of hip joint pain in children with severe cerebral palsy	Jozwiak (2011)	Disability and Rehabilitation	Poland
37	Prediction of hip displacement in children with cerebral palsy: development of the CPUP hip score	Hermanson (2015b)	Bone Joint J	Sweden
38	Pelvic obliquity and measurement of hip displacement in children with cerebral palsy	Hägglund (2018)	Acta Orthop	Sweden
39	Association between pelvic obliquity and scoliosis, hip displacement and asymmetric hip abduction in children with cerebral palsy: a cross-sectional registry study	Hägglund (2020)	BMC Musculoskelet Disord	Sweden
40	Utility of combined hip abduction angle for hip surveillance in children with cerebral palsy	Divecha (2011)	Indian Journal of Orthopaedics	India
41	Proximal femoral geometry before and after varus rotational osteotomy in children with cerebral palsy and neuromuscular hip dysplasia	Davids (2013)	J Pediatr Orthop	USA

42	Reliability of radiologic measures of hip displacement in a cohort of preschool-aged children with cerebral palsy	Craven (2014)	J Pediatr Orthop	Austrailia
43	Acetabular Remodeling After a Varus Derotational Osteotomy in Children With Cerebral Palsy	Chang (2016)	J Pediatr Orthop	USA
44	Proximal femoral osteotomy in children with cerebral palsy: the perspective of the trainee	Zhou (2017)	Journal of Childrens Orthopaedics	Austrailia
45	Clinical and radiographic results of multilevel surgical interventions for hip subluxation and dislocation in children with cerebral palsy	Tomov (2018)	Genij Ortopedii	Russia
46	The head–shaft angle of the hip in early childhood	List (2015b)	Bone Joint J	Netherlands
47	Assessment of hip displacement in children with cerebral palsy using machine learning approach	Pham (2021)	Med Biol Eng Comput	Canada

Table iv: Study details and patient characteristics.

Study ID	Study type	Patients (controls)	No. of hips	Age	Sex (% female)	Duration of follow up	Timepoint of assessment	Primary intervention
1	prospective	67	128	Mean:14y7m SD:1y5m	42%	Not specified	latest radiograph of the pelvis and hip joints taken for CPOP. If the latest radiograph was taken before 2017, the respondent was asked to permit a new radiograph to be taken.	hip surveillance programme
2	retrospective	108	214	Mean:9.4y SD:3.2y	30%	5.2 years	Pre- + postoperative	HRS (hip reconstructive surgery) including FVDO
3	retrospective	179	291	Mean:7.8y SD:3.3y	43%	3.9±2.1 years	Preoperative	HRS (hip reconstructive surgery) including femoral osteotomy, both a femoral osteotomy and a concurrent acetabular

								osteotomy and isolated acetabular osteotomy
4	retrospective	71	85	Mean:8.4y SD:3.2y	52%	6.6 ± 3.1 years	Pre- + postoperative (including follow up)	VDRO combined with modified Dega osteotomy
5	retrospective	76	144	Mean:8.5y SD:2.3y	25%	4.9 years (SD, 2.4 years; range, 1.0 to 9.8 years)	Pre- + postoperative (including follow up - at least 2 years)	reconstructive surgery (femoral varus derotational osteotomy alone or combined with a modified Dega pelvic osteotomy)
6	retrospective	72	72	Median:7.6y Range:4.7–16.3y	38%	7.7 years (4.9 to 11.8)	Pre- + postoperative (including follow up)	single-event multilevel surgery (SEMLS) in combination with hip reconstruction by using a periacetabular osteotomy as described by

								Dega concerning post-operative remodeling and plasticity of the femoral head post-operatively
7	cross-sectional	1171	Not specified	Mean:7.88y	Not specified	N/A	first hip radiograph as part of the CPIPS programme	hip surveillance programme
8	retrospective	54	64	Mean:9.1y SD:3.3y Range:4.0–16.5y	37%	43.9 ± 19.5 months (range 3–72).	Pre- + postoperative (including follow up)	simultaneous soft tissue release, VDRSO, and PPO
9	retrospective	53	Not specified	Mean:7.9y SD:2.2y	43%	5.3 years with minimal follow up of 12 months.	Pre- + postoperative (including follow up)	bilateral selective dorsal rhizotomy
10	retrospective	91	179	Mean:4.6y SD:1.6y Range:2.4-10.6y	36%	5.4 (1.03-10.20)	Pre- + postoperative (most recent preoperative radiograph and all available postoperative	isolated **femoral** varus derotational osteotomy (VDRO)

							anteroposterior pelvis radiographs.)	
11	cross-sectional	75	Not specified	Median:7.7y IQR:6.5y	44%	N/A	Not specified	hip surveillance programme
12	retrospective	57	Not specified	Mean:9.3y SD:1.8y Range:7–14y	46%	68.4 months (SD=22.0; range, 60–124 months). Duration between P/Ex and imaging study (mo)	Preoperative (between baseline physical exam and pre-operative evaluation for ortho paedic surgery)	Nil
13	retrospective	100 (103)	Not specified	Mean:8.8y SD:4.3y Range:3–18y	Not specified	7.5 (range 5–10) years	taken in A&E during a 6-month period	hip surveillance programme
14	retrospective	50 Group 1: 19 Group 2: 23 Group 3: 8	100	<u>Group 1</u> Mean:12y SD:2y Range:8–15y <u>Group 2</u> Mean:12y SD:1.7y Range:8–15y <u>Group 3</u>	56%	Group 1: 54 ± 30 (6–129) months of follow-up Group 2: 45 ± 32 (range 4–	pre- + post- spinal fusion surgery	spinal fusion with pelvic fixation

				Mean:12y SD:2y Range:8–12y Overall range:7.5–15.0y			98) months of follow-up Group 3: 50 ± 39 (range 3–129) months of follow-up		
15	cross-sectional	93	Not specified	Mean:6.8y SD:3y Range:2.4–12y	43%	10.3 years (SD = 6) years	Pre- + postoperative		soft tissue surgery as the first treatment for hip displacement
16	cross-sectional	255 (119 Norwegian + 136 Swedish)	Not specified	<u>Sweden</u> Mean:5.7y SD:2.3y <u>Norway</u> Mean:7.6y SD:2.9y	45.6% in Sweden + 38.7% in Norway	N/A	most recent or preoperative		hip surveillance programme
17	retrospective	71	140	Mean:7y Range:3-12y	41%	12.8 years (1.0/27.0)	The measurement was taken twice; the first one was taken as close in time as possible before surgery (up to 3 months before) and the second		Soft tissue release of the spastic hip by psoas–rectus transfer and

							radiograph on the day of the last reassessment.	adductor tenotomy
18	retrospective	145	Not specified	Mean:3.5y Range:0.6-9.7y	50%	Not specified	first radiograph in CPUP + a follow-up period of 5 years or until development of MP > 40% of either hip within 5 years	Hip surveillance programme
19	retrospective	75	116	Mean:7.0y Range:2.1-12.1y	40%	4.6 years (range, 2.0 to 10.7 y)	Pre- + postoperative (including follow up)	isolated varus derotational osteotomy (VDRO) + VDRO combined with open hip reduction and/or pelvic osteotomy
20	prospective	1115	Not specified	Not specified	42%	1.2 years (range 1 month –5 +8yrs)	During hip surveillance program (multiple timepoints - not specified)	Hip surveillance programme
21	retrospective	353	Not specified	Not specified	Not specified	Not specified ?	Before 3 years of age + follow up between 2-7 years	Hip surveillance programme
22	retrospective	50	100	Not specified	30%	Not specified ?	age of two years (12–32 months; T1), age of four years (36–60 months; T2) and	Nil

							age of seven years (72–96 months; T3)	
23	prospective	124	Not specified	Mean:7.01y SD:2.47y Range:3–13y	Not specified	At least 30 months	Pre- + postoperative (including follow up - annually)	reconstructive surgery for hip dislocation with also simultaneous surgical interventions for: contractures of the knee joints and/or contractures of the ankle joints and foot deformities
24	retrospective	110	150	Mean:8.7y SD:2.4y Range:2.8-13.8y	38%	2.9 ± 2.6 (1.0 to 12.0)	Pre- + postoperative (including follow up)	Dega pelvic osteotomy using iliac crest allograft
25	prospective	77	154	Mean:9.5y SD:1.6y Range:7–12y	38%	Not specified	radiograph taken nearest to the time that the questionnaire (pain assessment) was answered	Nil
26	retrospective	1,171	Not specified	Mean:7.9y Range:2-16y	Not specified	N/A	Pre- + post-CPIPS	hip surveillance programme

27	retrospective	101	Not specified	Mean:2.4y Range:0.8-4.9y	40%	4.3 years (range, 0.9 to 11.8 y)	At diagnosis + at the last follow-up or last preoperative radiograph	hip surveillance programme
28	retrospective	119	224	Mean:8.9y SD:2.7y Range:2.8 to 16.5y	34%	3.3 ± 2.7 (1 to 11.9)	Pre- + postoperative (including follow up - at least two follow-up evaluations)	hip reconstructive surgery including FVO (femoral varization osteotomy)
29	retrospective	81	115	Mean:9y Range:3.5-13.8y	49%	5.5 years (1.6 to 15.1)	Pre- + postoperative (including follow up - one year post-operatively and at final review)	open reduction of the hip
30	prospective	335	Not specified	Mean:3y Range:6m–7y 11m	44%	2 years 9 months (range 6mo–7y 3mo)	CPOP: Initial radiograph (shortly after diagnosis, preferably at the age of 1 year, in children with pronounced spasticity OR for all other children, a radiograph at the age of 2 years) +	hip surveillance programme

							last follow up radiograph (until operative treatment for hip displacement or until the most recent radiograph in those who had not undergone hip surgery)	
31	retrospective	239	346	Mean:11.6y Range:3-18y	38%	6.5 (2 to 14.8)	birth through to the date of analysis	hip surveillance programme
32	retrospective	55	102	Median:6.5y Range:3.2–15.6y	54%	7.4 years (range 3–11 years)	Pre- + postoperative (including follow up - within the first year (postoperative), and then at ~ 1-year follow-up intervals for a minimum of 2 years and a maximum of 11 years)	isolated varus derotational osteotomy (VDRO)
33	prospective	67	Not specified	Mean:9y Range:7–12y	40%	Not specified	radiograph taken nearest to the time the questionnaire	hip surveillance programme

							was answered. The mean length of time between radiograph and questionnaire was 5.4 (0–25) months, and no surgery was performed during this interval.	
34	prospective	235	Not specified	Mean:6y4m Range:2y 4m-10y11m)	55%	median follow-up of 2.7 years (range 0.4–6.3; mean 2.6)	baseline and at each annual visit	Nil
35	retrospective	72	144	Mean:6.2y Range:3.2-12.2y	33%	7.0 (2.0 to 16.0) years	Preoperative, postoperative, and final follow-up radiographs	bilateral VDROs without concomitant pelvic osteotomy
36	cross-sectional	73	99	Mean10.8y Range:4.0–18.0y	42%	N/A	Not specified	physiotherapy (abduction treatment and horse-back riding therapy)
37	prospective	145	Not specified	Mean:3.5y Range:0.6-9.7y	50%	Not specified (followed up until hip displacement (MP > 40%) occurred (group 1) or for five years without hip	CPUP: first radiographic examination (MP & HSA) + MP was then measured prospectively once	hip surveillance programme

						displacement (group 2))	a year according to the CPUP schedule until hip displacement (MP > 40%) occurred (group 1) or for five years without hip displacement (group 2).	
38	cross-sectional	268	Not specified	Not specified (children < 18 years)	44%	N/A	CPUP: First pelvic radiograph in CPUP during study period	hip surveillance programme
39	cross-sectional	337	Not specified	Not specified	45%	N/A	CPUP: First pelvic radiograph in CPUP during study period	hip surveillance programme
40	cross-sectional	103	206	Mean:5.03y Range:2–11y	53%	N/A	Not specified	hip surveillance programme
41	retrospective	75	137	Mean:7y SD:2y8m Range:3y2m-17y5m	44%	5 years and 6 months (range, 1 to 12 y and 7 mo)	preoperative, postoperative, and follow-up	Varus Rotational Osteotomy
42	cross-sectional	133	Not specified	Median:35.6m Range:30.5-36.4m	36%	Not specified (18, 24, 30, 36, 48, and 60 months)	During hip surveillance (at 18, 24, 30, 36, and 48 months)	hip surveillance programme

43	retrospective	87 (917)	174	Mean:4.6y SD:1.6y Range:2.4-10.6 y	Not specified	5.1 ± 2.2 years (range, 1.1 to 9.9 y)	NSA (intraoperatively), ADR (preoperative and postoperative - but may not be relevant)	isolated varus derotation osteotomy
44	prospective	90	180	Mean:7y11m Range:4y3m-13y 9m	47%	mean 28 months; 21 to 40	Pre- + postoperative (including follow up - three, six and 12 weeks and at six and 12 months following surgery and yearly thereafter)	Proximal femoral osteotomy
45	Retrospective	50	Not specified	Mean:6.2y SD:1.37y	Not specified	2.8 ± 1.7 years (mean)	Pre- + postoperative	Surgery
46	Retrospective	50	100	Mean: T1:24m T2:49m T3:84m	30%	Not specified	Different age intervals	None
47	retrospective	122	Not specified	Not specified Range:4–10y	Not specified	Not specified	Not specified	None

Table v: Measurements reported per article with definitions.

Study ID	Measurement	Verbatim written definition	Visual aid
1	RMP[1]	Not specified	No
2	RMP	MP was calculated by dividing the width of the femoral head lateral to the Perkin's line by the total width of the femoral head	Yes
	NSA[2]	NSA was defined as the angle between a line passing through the centre of the femoral shaft and another line connecting the femoral head centre and the midpoint of the femoral neck	No
	MHR[3]	Concentric circles were drawn at the centre of the femoral head with the larger circle outlining the outer cortex of the femoral head and the inner circle outlining the innermost cortex of the head. The ratio between the radii of the two circles was calculated as the sphericity of the femoral head	Yes
3	RMP	Migration percentage (MP) measured as MP = (A/B) ×100.]	Yes
	AcI[4]	AI measured as the angle formed by Hilgenreiner's line and a line draw from the lateral triradiate cartilage to the lateral acetabular margin	Yes
	NSA	NSA measured as the angle formed by a line bisecting the femoral head (crossing the epiphysis at 90 degrees) and a line formed along the axis of the femoral shaft.	Yes
4	RMP	Not specified	No
	CEA[5]	Not specified	No
	AA[6]	Not specified	No
5	NSA	On the left hip, the neck-shaft angle (NSA) was defined as the angle between a line passing through the center of the femoral shaft and another line connecting the femoral head center and the midpoint of the femoral neck. The femoral head center was the center of the largest best-fitting circle inside the femoral head.	Yes
	HSA[7]	Not specified	No
	RMP	On the right hip, the migration percentage (MP) was calculated by dividing the width of the femoral head lateral to Perkin's line (A) by the total width of the femoral head (B).]	Yes
6	RMP	Not specified	No
	CEA	Not specified	No

7	RMP	Not specified	No
8	RMP	Not specified	No
	AA	Not specified	No
9	CEA	Not specified	Yes
	RMP	Not specified	Yes
10	Shenton's line	Not specified	No
	RMP	Not specified	No
11	RMP	MP is obtained by identifying Hilgenreiner's line (H) and Perkin's line (P) and then measuring the proportion (%) of capital epiphysis that has migrated beyond Perkin's line laterally (A/B x 100).]	Yes
	AcI	AI as the angle between the slope of the acetabulum and Hilgenreiner's line	Yes
12	RMP	Measurement of migration percentage (MP). MP=B/A×100. Hilgenreiner's line and Perkins line are marked as 'H' and 'P'. MP is the proportion (%) of the capital epiphysis that appears to lie outside the acetabulum.	Yes
	NSA	Measurement of the femoral neck and shaft angle (FNS). 'a' is the FNS measurement, performed in standard anterior-posterior X-rays of the proximal femur or pelvis, which was generated by the intersection angle between the femoral neck axis and femoral shaft axis.	Yes
13	RMP	Not specified	Yes
	HSA	Not specified	Yes
14	RMP	migration index (x/y × 100)	Yes
	AA	acetabular angle (narrow angle between yellow lines)	Yes
15	RMP	Not specified	Yes
	AcI	Not specified	Yes
	HSA	Not specified	Yes
16	RMP	Not specified	No
17	RMP	Not specified	No
	AcI	Not specified	No
	NSA	Not specified	No

18	RMP	migration percentage (MP), calculated as b/c × 100, on the left hip	Yes
	HSA	HSA: The HSA is measured by drawing a line midway through the femoral shaft and then drawing another line perpendicular to the proximal femoral physis through the center of the proximal femoral epiphysis	Yes
19	RMP	Not specified	No
	AcI	Not specified	No
	AA	Not specified	No
	NSA	Not specified	No
	CEA	Not specified	No
20	RMP	Not specified	No
21	RMP	Measurement of Migration Percentage (MP). MP = A/B 9 100. On the right hip with a "Gothic arch" formation of the lateral margin, the midpoint of the arch is used as reference point	Yes
22	RMP	the migration percentage (MP) is measured by a Hilgenreiner's line (H) and three perpendicular lines. The MP is measured by A/B x 100 %	Yes
	HSA	head-shaft angle (C) by measuring the medial angle between a line perpendicular to the proximal femoral epiphysis and a line through the middle of the femoral shaft.	Yes
23	RMP	Not specified	No
	AcI	Not specified	No
	ADR[8]	Not specified	No
	NSA	Not specified	No
	CEA	Not specified	No
24	NSA	neck-shaft angle (NSA) was defined as the angle between a line passing through the center of the femoral shaft and another line connecting the center of the femoral head and the midpoint of the femoral neck. The center of the femoral head was the center of the largest best-fitting circle inside the femoral head	Yes
	RMP	Migration percentage (MP) was calculated by dividing the width of the femoral head lateral to Perkin's line (a) by the total width of the femoral head (b)	Yes
	AcI	Acetabular index (AI) was defined as the angle between the acetabular roof and the Hilgenreiner's line	Yes

25	RMP	MP is the percentage of the femoral head lateral to the acetabulum (lateral to Perkins' line), measured parallel to Hilgenreiner's line.	No
26	RMP	Not specified	No
27	RMP	MP is the percentage of the femoral head lateral to the acetabulum (lateral to Perkins' line). + Measurement of the migration percentage (MP) is shown in the left hip (MP = a/b×100)	Yes
	HSA	The head-shaft angle (HSA) is the medial angle between a line perpendicular to the proximal femoral physis and a line through the middle of the femoral shaft	Yes
28	NSA	NSA was defined as the angle between a line passing through the center of the femoral shaft and another line connecting the femoral head center and the midpoint of the femoral neck. The femoral head center was the center of the largest best-fitting circle inside the femoral head.	Yes
	HSA	HSA was defined as the angle between a line passing through the center of the femoral shaft and another line perpendicular to the proximal femoral physis passing through the center of the proximal femoral epiphysis	Yes
	RMP	RMP was calculated by dividing the width of the femoral head lateral to Perkin's line (A) by the total width of the femoral head	Yes
29	RMP	Not specified	No
	AcI	Not specified	No
	ESA[9]	Not specified	No
	PFA[10]	Not specified	No
30	RMP	RMP the percentage of the femoral head lateral to the acetabulum (lateral to Perkins' line), measured parallel to Hilgenreiner's line.	Yes
	AcI	AI as the slope of the acetabular roof, which is the angle between the acetabular roof and Hilgenreiner's line	Yes
31	RMP	Not specified	No
32	NSA	Not specified	No
	AcI	Not specified	No
	RMP	Not specified	No
	CEA	Not specified	No

33	RMP	RMP as the percentage of the femoral head lateral to the acetabulum (lateral to Perkins' line), measured parallel to Hilgenreiner's line.	No
34	RMP	Not specified	Yes
35	RMP	Not specified	No
	AcI	Not specified	No
	NSA	Not specified	No
	HSA	Not specified	No
36	RMP	Not specified	No
37	RMP	Hilgenreiner's and Perkins lines; b: is the horizontal distance that the femoral head has translated lateral to Perkins line, c: is the horizontal measurement of the femoral head medial to Perkins line. The MP is b/c × 100	Yes
	HSA	HSA was measured by the angle intersecting two lines; one passing through the proximal mid diaphyseal line of the femoral shaft and a second perpendicular to the proximal femoral physis	Yes
38	RMP	Not specified	Yes
	PAMP[11]	Not specified	Yes
39	RMP	Not specified	No
40	RMP	Not specified	No
41	NSA	The femoral shaft and neck axes were drawn on the radiographic film, and the NSA was measured as the angle subtended by the intersection of these 2 axes. To define the shaft axis 2 lines were drawn perpendicular to the diaphysis of the femur. A line connecting the midpoints of these 2 lines was then drawn to represent the shaft axis. The neck axis was defined in a similar manner utilising 2 lines drawn through the proximal and distal margins of the middle third of the femoral neck. The head axis was determined by drawing a line perpendicular to the proximal femoral physis. The HSA was calculated from the relation between the head and shaft axes	Yes
	HSA		Yes
	MeI[12]	The MeI was determined by dividing the distance between the proximal physis and the lateral margin of the greater trochanter on the neck axis line (described above for NSA) by the distance between the proximal physis and the intersection with the shaft axis line (described above for NSA) on the neck axis line. The greater the MeI, the greater the medialisation of the femoral shaft.	Yes
42	RMP	Not specified	No

	HEA[13]	HEA as the acute angle between a line drawn parallel to and through the proximal femoral epiphysis and Hilgenreiner line (HL).	Yes
	AcI	Not specified	No
	NSA	Not specified	No
43	NSA	Not specified	No
	ADR	The acetabular depth ratio (ADR), where A is the depth and B is the width. The width B is measured as the distance from the inferior teardrop to the lateral edge of the sourcil and the depth A is the perpendicular distance from the midpoint of B to the deepest point of the acetabular roof. ADR = A/BÂ100. This hip has an ADR of 24	Yes
44	RMP	Not specified	No
	NSA	Not specified	No
45	RMP	Not specified	No
	AcI	Not specified	No
	ADR	Not specified	No
	NSA	Not specified	No
	CEA	Not specified	No
46	HSA	The head–shaft angle (HSA) is the medial angle between a line perpendicular to the proximal femoral epiphysis and a line through the middle of the femoral shaft.	Yes
47	RMP	Migration percentage MP is defined as the ratio of the femoral head migrated beyond the acetabular edge (a) to the total width of the femoral head (b).	Yes

AA, Acetabular angle or Sharp's angle; AcI, acetabular index; ADR, acetabular depth ratio; CEA, centre edge angle of Wiberg; ESA, epiphyseal shaft angle; HEA, Hilgenreiner epiphyseal angle; HSA, femoral head-shaft angle; MeI, Medialization index; MHR, Mose hip ratio; NSA, femoral neck-shaft angle; PAMP, pelvic adjusted migration percentage; PFA, pelvic femoral angle; RMP, Reimers' migration percentage.

Table vi: Delphi round one responses.

Reimer's migration percentage (RMP) and Mose hip ratio (MHR) were both voted out in round one; therefore, they were not scored by participants in round two. Sourcil Tönnis angle (STA) and Femoral head shape/congruency (FHS) were only suggested in round one; therefore, these measurements were only scored by the participants in round two. Participant 9 did not take part in round two of the Delphi process.

ID	Round	Time (min:sec)	RMP	HSA	NSA	MHR	AcI	CEA	AA	SL	ADR	ESA	HEA	PFA	PAMP	MeI	STA	FHS
1	R1	01:04	9	1	7	1	1	1	1	1	1	1	1	1	1	1	N/A	N/A
	R2	03:26	N/A	1	9	N/A	1	1	1	5	1	1	1	1	1	1	1	1
2	R1	08:28	9	7	7	3	7	5	3	6	3	5	3	3	3	3	N/A	N/A
	R2	05:20	N/A	6	7	N/A	6	3	3	7	3	5	3	2	5	3	1	7
3	R1	03:15	9	5	5	3	7	7	7	6	3	3	3	3	4	3	N/A	N/A
	R2	04:42	N/A	5	5	N/A	6	4	5	7	5	5	4	5	4	3	5	7
4	R1	02:48	9	6	8	1	4	2	2	7	6	3	3	3	3	3	N/A	N/A
	R2	02:52	N/A	6	7	N/A	7	3	3	7	3	3	3	3	3	3	3	7
5	R1	01:28	9	1	4	1	1	1	1	5	1	1	1	1	1	1	N/A	N/A
	R2	02:42	N/A	3	7	N/A	3	3	1	7	1	1	1	1	1	1	2	8
6	R1	03:08	9	5	5	5	7	5	5	9	5	5	5	5	9	5	N/A	N/A
	R2	05:40	N/A	6	7	N/A	7	3	3	7	3	1	3	1	5	3	5	9
7	R1	01:20	9	8	7	6	8	6	7	8	7	6	7	6	8	6	N/A	N/A
	R2	02:34	N/A	7	7	N/A	9	7	7	8	3	3	3	3	3	3	7	8
8	R1	05:20	9	6	4	2	5	3	5	6	4	4	4	4	4	3	N/A	N/A
	R2	02:49	N/A	7	7	N/A	4	2	2	5	3	2	3	2	2	3	3	5
9	R1	01:40	9	6	6	4	9	8	7	9	7	3	6	3	4	4	N/A	N/A
	R2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

10	R1	01:34	9	7	9	7	8	6	6	8	6	5	7	5	5	5	N/A	N/A
	R2	01:35	N/A	3	7	N/A	8	5	6	7	3	1	1	1	2	2	5	7
11	R1	01:27	6	3	6	3	7	3	7	2	2	3	3	7	8	6	N/A	N/A
	R2	04:19	N/A	5	8	N/A	8	5	5	2	7	7	8	2	3	4	5	8
12	R1	03:54	9	3	7	7	9	7	6	7	4	4	4	6	6	4	N/A	N/A
	R2	02:43	N/A	5	8	N/A	9	7	5	6	5	5	5	5	8	5	7	9
13	R1	02:43	9	8	8	6	9	5	8	6	5	6	6	6	7	5	N/A	N/A
	R2	03:51	N/A	7	7	N/A	8	5	7	8	5	5	5	7	7	4	4	7
14	R1	02:04	9	6	7	1	3	1	1	1	1	1	1	1	1	1	N/A	N/A
	R2	04:56	N/A	6	7	N/A	2	2	2	2	2	2	2	1	2	2	2	8
15	R1	1192:27	9	7	6	1	8	3	5	7	3	1	7	1	1	1	N/A	N/A
	R2	11:06	N/A	7	8	N/A	8	3	6	9	3	3	7	2	3	1	8	8
16	R1	16:11	9	6	2	2	3	2	3	7	3	1	2	2	6	2	N/A	N/A
	R2	05:16	N/A	7	4	N/A	7	1	3	7	3	1	1	1	5	1	3	5
17	R1	05:08	9	7	6	1	5	1	1	4	1	4	1	1	1	1	N/A	N/A
	R2	05:53	N/A	7	6	N/A	7	2	1	6	2	3	2	1	3	2	2	6
18	R1	02:48	9	6	3	3	9	3	8	7	5	7	5	3	3	3	N/A	N/A
	R2	03:21	N/A	6	3	N/A	8	2	2	8	1	1	3	3	1	1	2	6
19	R1	02:30	9	9	3	3	3	3	3	3	3	3	3	3	3	3	N/A	N/A
	R2	06:57	N/A	2	9	N/A	1	1	1	1	1	1	1	1	1	1	1	1
20	R1	03:19	9	3	8	1	8	3	3	6	2	2	2	2	6	2	N/A	N/A
	R2	05:05	N/A	3	6	N/A	7	3	2	6	2	3	3	2	3	3	3	6
21	R1	01:53	9	8	6	3	6	2	2	7	3	7	3	2	3	2	N/A	N/A
	R2	04:54	N/A	8	5	N/A	7	2	3	7	2	8	5	2	5	1	2	6
22	R1	01:54	9	4	1	2	7	3	2	6	3	6	4	2	2	2	N/A	N/A
	R2	02:52	N/A	2	1	N/A	7	1	1	4	1	4	3	1	1	1	1	1