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# Postural asymmetries, pain, and ability to change position of children with cerebral palsy in sitting and supine: a cross-sectional study

Jackie Casey<sup>a,b</sup> , Andreas Rosenblad<sup>c</sup>  and Elisabet Rodby-Bousquet<sup>a,d</sup> 

<sup>a</sup>Department of Clinical Sciences, Orthopedics, Lund University, Lund, Sweden; <sup>b</sup>Regional Rehabilitation Engineering Centre, Musgrave Park Hospital, Belfast Health & Social Care Trust, Belfast, Northern Ireland; <sup>c</sup>Department of Medical Sciences, Clinical Diabetology and Metabolism, Uppsala University, Uppsala, Sweden; <sup>d</sup>Centre for Clinical Research, Uppsala University-Region Västmanland, Västerås, Sweden

## ABSTRACT

**Purpose:** To examine any associations between postural asymmetries, postural ability, and pain for children with cerebral palsy in sitting and supine positions.

**Methods:** A cross-sectional study of 2,735 children with cerebral palsy, 0-18 years old, reported into the Swedish CPUP registry. Postural asymmetries, postural ability, the gross motor function classification system levels I–V, sex, age and report of pain were used to determine any relationship between these variables.

**Results:** Over half the children had postural asymmetries in sitting ( $n = 1,646$ ; 60.2%) or supine ( $n = 1,467$ ; 53.6%). These increased with age and as motor function decreased. Children were twice as likely to have pain if they had an asymmetric posture (OR 2.1–2.7), regardless of age, sex and motor function. Children unable to maintain or change position independently were at higher risk for postural asymmetries in both supine (OR 2.6–7.8) and sitting positions (OR 1.5–4.2).

**Conclusions:** An association was found between having an asymmetric posture and ability to change position in sitting and/or lying; and with pain. The results indicate the need to assess posture and provide interventions to address asymmetric posture and pain.

## ARTICLE HISTORY

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## KEYWORDS

Cerebral palsy; children; pain; posture; sitting position; supine position

## ► IMPLICATIONS FOR REHABILITATION

- Postural asymmetries are present in children with cerebral palsy at all levels of gross motor function.
- Postural asymmetries increase with age and are associated with pain.
- Assessment of posture should be included in surveillance programs to enable early detection and treatment.

## Introduction

Cerebral palsy (CP) is the most common cause of motor impairments in childhood, with a prevalence in Europe of 2.2–2.5/1000 children [1–3]. Although CP is reported as primarily a neurological motor disorder, complications can arise affecting different body systems [3] and especially for those who have posture and mobility limitations compromising their ability to move, reposition and remain stable against gravity [4].

Posture refers to the anatomical alignment of body segments in relation to each other and to the support surface [5]. Postural ability relates to the individual's ability to stabilize these body segments relative to each other and to the supporting surface during static and dynamic conditions; to maintain and change position in order to participate in activities [5].

Approximately one-third of children with CP are non-ambulant and subsequently spend prolonged periods of time in sitting or lying [1]. This can lead to postural asymmetries [6], and ultimately to tissue adaptation [4,7], pain [8,9], and deformities commonly affecting the spine and lower extremities [4,10–12].

Pain increases with age and is more frequently located in the feet in children at Gross Motor Function Classification System (GMFCS) levels I–II and in the hips and spine in children at GMFCS levels IV–V [13]. Pain can lead to reduced engagement in everyday life [13–16], especially school work, sleep [13,17], and quality of life [18], including mental health [19].

Although there is a growing evidence of the prevalence and impact of postural asymmetries in adults with CP [4,7,12,20], little is known about the postural asymmetries of children, nor of their ability to change position in sitting and lying and its relationship with pain.

Against this background, the purpose of this study was to examine any associations between postural asymmetries, postural ability, and pain for children with CP in sitting and supine positions.

## Materials and methods

### Ethical approval and consent

The study was approved by the Medical Research Ethics Committee at Lund University (LU 383/2007) and permission to

CONTACT Jackie Casey  [jackie.casey@med.lu.se](mailto:jackie.casey@med.lu.se)  Department of Clinical Sciences, Orthopaedics, Lund University, S-221 85 Lund, Sweden

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extract data was obtained from the CPUP registry. The legal caregiver of all participants consented to research based on the data held in the registry.

### Study design and participants

A cross-sectional study was performed based on Swedish children followed by the National Follow-up Program for People with Cerebral Palsy (CPUP) and reported into their Registry from 1 January 2017 to 30 June 2018. All children with suspected CP are offered the opportunity to participate in this program, and over 95% participate [2] and are included in the CPUP registry [21].

Inclusion criteria were data reported for the primary outcome variable posture in either sitting or supine lying. Children with no data of posture were excluded. CP diagnosis was given from the age of 4 years by neuropaediatricians according to the definition by Rosenbaum et al. [22] with inclusion and exclusion criteria as given by the Surveillance of Cerebral Palsy in Europe [23] with a brain injury before the age of 2 years and a dominating neurological symptom of either spasticity, ataxia, or dyskinesia. The 1–2% included in the registry who turn out not to have CP are then removed from it. Children are reviewed twice a year by their local occupational and physiotherapists until their sixth birthday and then annually thereafter [2].

### Measurements

Each child's gross motor function was classified by their local physiotherapist using the expanded and revised version of the GMFCS [24]. The GMFCS assesses the child's ability to sit, transfer and mobilize, and is used to classify the children into one of the five levels (I–V) based upon their functional limitation and the need for mobility devices, with higher levels indicating more severe functional limitations and need for mobility devices.

The participants' posture and ability to maintain or change position were rated by their local physiotherapist according to the Posture and Postural Ability Scale (PPAS) [5,25] in sitting and supine positions. The PPAS has excellent inter-rater reliability and validity for children and adults with CP [5,25]. Quality of posture is rated with six items from the frontal view and six items from the sagittal view, where postural alignment and symmetry gives 1 point per item while asymmetry or deviation from midline gives 0 points. These are then added to give a total score (0–6 points) for each position across each plane.

Postural ability is rated on a 7-point ordinal scale ranging from level 7 ("Able to move into and out of position") to level 1 ("Unplaceable in an aligned position"). Rating was completed on the individual's habitual posture on a plinth. Participants were asked to assume each of the positions (supine lying, prone lying, and sitting) as per the protocol described in Rodby-Bousquet et al. [5]. When participants were unable to independently maintain a position, manual support was provided to enable them to stay in the position. Those unable to assume or move in or out of a position were placed into that position.

Postural asymmetries were grouped into the four categories "severe" (0–1 point), "moderate" (2–3 points), or "mild" asymmetries (4–5 points), or "full" symmetry/no asymmetry (6 points) meaning a symmetric posture with head midline, trunk symmetrical, pelvis neutral, legs separated and straight relative to pelvis, arms resting or feet neutral and even weight distribution, and also dichotomized into having asymmetries (0–5 points) or no asymmetry (6 points).

Likewise, postural ability was grouped into four categories, with children able to independently move into and out of supine

or sitting position (PPAS level 7) grouped as "changes position", while children with mild postural deficit (PPAS level 5–6) were grouped as "moves within position", those with moderate postural deficit (PPAS level 3–4) were grouped as "maintains position", while children with severe postural deficit (PPAS levels 1–2) were grouped as "cannot maintain position". Postural ability was also dichotomized into "able to change position" (PPAS level 7) or "unable to change position" (PPAS levels 1–6).

Presence of pain was self-reported by the child or proxy (parent/primary caregiver), with the answer "yes" or "no" to the question "Do you/does the person experience pain?" [26]. All current pain was included regardless of pain site and pain severity. The pain assessment has previously been validated against medical records and described in detail by Westbom et al. [26]; while age was categorized into six groups (0–3, 4–6, 7–9, 10–12, 13–15, or 16–18 years old).

### Statistical analyses

Categorical data were described by frequencies and percentages,  $n$  (%), while continuous data were reported as means with accompanying standard deviations (SDs). Pearson's  $\chi^2$ -test and  $\chi^2$ -test for trend were used for tests of differences between categorical variables, while Spearman's rank correlation  $r_s$  was used for estimating correlations. Simple and multiple logistic regression models were used for estimating the magnitude of associations, with the results presented as odds ratios (ORs) with accompanying 95% confidence intervals (CIs). The OR for having pain was estimated using postural asymmetry (four categories) and inability to change position (four categories) as independent predictors, adjusted for age (categorized), sex, and GMFCS level. The OR for postural asymmetry (PPAS 0–5 points) was estimated using inability to change position (four categories), age (continuous), sex, and GMFCS level as independent predictors. Full postural symmetry (PPAS 6 points), ability to change position (PPAS level 7), lower age (0–3 years), male sex and better gross motor function (GMFCS I) were used as reference categories in the regression models. Statistical analyses were performed in IBM SPSS Statistics 26.0 and R 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria), with  $p$ -values <0.05 considered statistically significant.

## Results

### Participants

In total 2,735 (83%) of all 3,296 children reported into the CPUP registry were eligible for inclusion in this study. There were 1,628 boys (59.5%) and 1,107 girls with a mean (SD) age of 9.2 (4.4) years with data of posture in either sitting or supine position (Table 1). The largest group of children ( $n=1,132$ ; 41.4%), were classified at GMFCS level I, whilst the distribution varied from 10.8% to 16.5% across GMFCS levels II–V (Table 1).

### Postural asymmetries

More children ( $n=1,646$ ; 60.2%) presented with postural asymmetries in sitting than in supine ( $n=1,467$ ; 53.6%). Of the 1,646 children with postural asymmetries in sitting, 1,092 had postural asymmetries in both the frontal and sagittal view, while 1,018 of the 1,467 had asymmetries in supine lying. Severe postural asymmetries were observed in 320 children in sitting (97 frontal, 58 sagittal and 165 both) and in 329 children in supine (169 frontal, 49 sagittal, and 111 both).

Postural asymmetries were associated with GMFCS level (Table 2), and with increasing age in both supine (OR 1.07 [95% CI

Table 1. Participant demographics of the 2,735 children with cerebral palsy and distribution of postural asymmetries by the level GMFCS level, age, sex, and postural ability.

Supine	Asymmetric supine posture frontal										Asymmetric supine posture sagittal									
	Total number of children		Severe 0-1 pts		Moderate 2-3 pts		Mild 4-5 pts		None 6 pts		Severe 0-1 pts		Moderate 2-3 pts		Mild 4-5 pts		None 6 pts			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%		
GMFCS																				
I	1132	41.4	2	0.8	22	6.5	141	23	967	63.5	5	2.2	15	4	161	23.7	951	65.1		
II	450	16.4	8	3.1	30	8.8	110	18	302	19.8	4	1.8	36	9.7	131	19.3	279	19.1		
III	295	10.8	8	3.1	44	13	101	17	142	9.3	10	4.5	52	14	102	15	131	9		
IV	434	15.9	57	22	128	37.8	161	26	88	5.8	54	24.2	138	37.1	171	25.2	71	4.9		
V	424	15.5	187	71	115	33.9	97	16	25	1.6	150	67.3	131	35.2	114	16.8	29	2		
Total	2735	100	262	100	339	100	610	100	1524	100	223	100	372	100	679	100	1461	100		
Age <sup>a</sup>																				
0-3	300	11	13	5	31	9.1	82	13.4	174	11.4	9	4	37	9.9	78	11.5	176	12		
4-6	580	21.2	41	15.6	47	13.9	130	21.3	362	23.8	30	13.5	63	16.9	141	20.8	346	23.7		
7-9	548	20	44	16.8	69	20.4	117	19.2	318	20.9	41	18.4	73	19.6	126	18.6	308	21.1		
10-12	576	21.1	59	22.5	83	24.5	126	20.7	308	20.2	55	24.7	79	21.2	147	21.6	295	20.2		
13-15	477	17.4	67	25.6	71	20.9	102	16.7	237	15.6	58	26	79	21.2	114	16.8	226	15.5		
16-18	254	9.3	38	14.5	38	11.2	53	8.7	125	8.2	30	13.5	41	11	73	10.8	110	7.5		
Total	2735	100	262	100	339	100	610	100	1524	100	223	100	372	100	679	100	1461	100		
Sex																				
Boys	1628	59	155	59	203	60	383	63	887	58	127	57	236	63	400	59	865	59		
Girls	1107	41	107	41	136	40	227	37	637	42	96	43	136	36	279	41	596	41		
Total	2735	100	262	100	339	100	610	100	1524	100	223	100	372	100	679	100	1461	100		
Postural Ability PPAS level																				
1	11	0.4	10	3.8	1	0.3	0	0	0	0	10	4.5	1	0.3	0	0	0	0		
2	90	3.3	54	20.7	24	7.1	9	1.5	3	0.2	48	21.5	22	6	17	2.5	3	0.2		
3	168	6.2	65	24.9	51	15	41	6.8	11	0.7	44	19.7	61	16.5	51	7.5	12	0.8		
4	163	6	43	16.5	52	15.3	51	8.4	17	1.1	43	19.3	43	11.7	64	9.5	13	0.9		
5	176	6.4	41	15.7	54	15.9	60	9.9	21	1.4	27	12.1	73	19.8	51	7.5	25	1.7		
6	216	7.9	25	9.6	44	13	93	15.3	54	3.6	25	11.2	56	15.2	78	11.5	57	3.9		
7	1903	69.8	23	8.8	113	33.3	353	58.2	1414	93	26	11.7	113	30.6	416	61.5	1348	92.5		
Total	2727	100	261	100	339	100	607	100	1520	100	223	100	369	100	677	100	1458	100		

<sup>a</sup>Mean (SD) 9.2 (4.4) years.

Table 1. Continued.  
(B) In sitting position

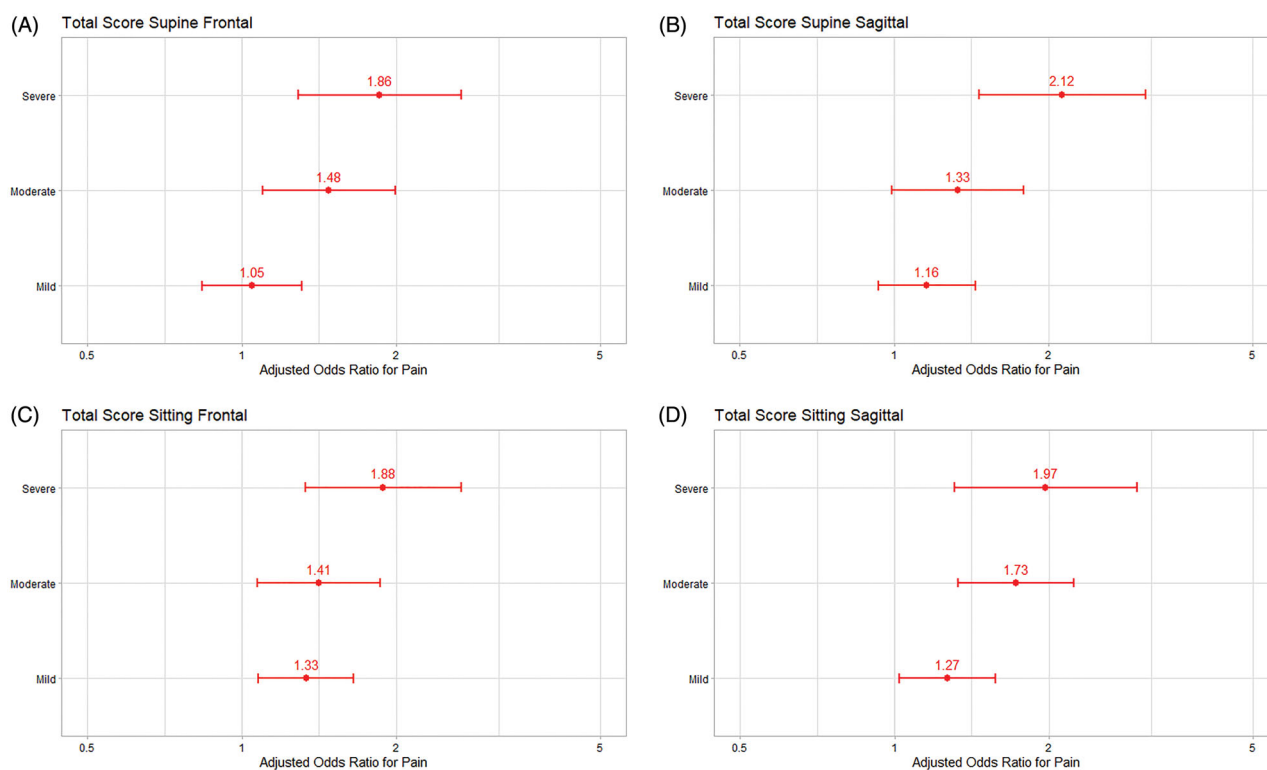
Sitting	Total number of children		Asymmetric sitting posture frontal						Asymmetric sitting posture sagittal									
			Severe		Moderate		Mild		Severe		Moderate		Mild		None			
			n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
GMFCS																		
I	1132	41.4	1	0.4	38	9.6	193	29.7	900	63.9	0	0	49	8.3	191	28.8	892	67.4
II	450	16.4	3	1.1	51	12.8	123	19	273	19.4	3	1.9	58	9.8	143	21.6	246	18.6
III	295	10.8	19	6.8	45	11.3	92	14.2	139	9.9	14	8.8	81	13.8	90	13.6	110	8.3
IV	434	15.9	76	27	136	34.3	145	22.3	77	5.5	36	22.5	210	35.7	130	19.6	58	4.4
V	424	15.5	181	65	127	32	96	14.8	20	1.4	107	66.9	191	32.4	109	16.4	17	1.3
Total	2735	100	280	100	397	100	649	100	1409	100	160	100	589	100	663	100	1323	100
Age <sup>a</sup>																		
0-3	300	11	19	6.8	31	7.8	87	13.4	163	11.6	24	15	49	8.3	66	10	161	12.2
4-6	580	21.2	45	16.1	79	19.9	143	22	313	22.2	28	17.5	112	19	141	21.3	299	22.6
7-9	548	20	51	18.2	86	21.7	115	17.7	296	21	24	15	117	19.9	136	20.5	271	20.5
10-12	576	21.1	63	22.5	89	22.4	130	20	294	20.9	34	21.3	129	21.9	140	21.1	273	20.6
13-15	477	17.4	62	22.1	74	18.6	113	17.4	228	16.2	33	20.6	123	20.9	116	17.5	205	15.5
16-18	254	9.3	40	14.3	38	9.6	61	9.4	115	8.2	17	10.6	59	10	64	9.7	114	8.6
Total	2735	100	280	100	397	100	649	100	1409	100	160	100	589	100	663	100	1323	100
Sex																		
Boys	1628	59.5	163	58	233	59	407	63	825	59	99	62	371	63	391	59	767	58
Girls	1107	40.5	117	42	164	41	242	37	584	41	61	38	218	37	272	41	556	42
Total	2735	100	280	100	397	100	649	100	1409	100	160	100	589	100	663	100	1323	100
Postural Ability PPAS level																		
1	9	0.3	9	3.2	0	0	0	0	0	0	5	3.2	3	0.5	0	0	1	0.1
2	578	21.3	200	72.2	177	44.7	157	24.3	44	3.1	116	73.4	267	45.6	158	23.9	37	2.8
3	69	2.5	17	6.1	23	5.8	21	3.3	8	0.6	9	5.7	35	6	19	2.9	6	0.5
4	95	3.5	17	6.1	25	6.3	33	5.1	20	1.4	6	3.8	40	6.8	35	5.3	14	1.1
5	128	4.7	7	2.5	30	7.6	46	7.1	45	3.2	6	3.8	54	9.2	32	4.8	36	2.7
6	116	4.3	6	2.2	23	5.8	42	6.5	45	3.2	6	3.8	36	6.2	38	5.7	36	2.7
7	1721	63.4	21	7.6	118	29.8	346	53.6	1236	88.4	10	6.3	150	25.6	379	57.3	1182	90.1
Total	2716	100	277	100	396	100	645	100	1398	100	158	100	585	100	661	100	1312	100

<sup>a</sup>Mean (SD) 9.2 (4.4) years.

**Table 2.** Logistic regression analyses with odds ratios (ORs) and 95% confidence intervals (CI) for asymmetric postures (PPAS 0–5 points) in sitting and supine positions.

	Asymmetric supine posture			Asymmetric sitting posture				
	OR	95% CI	<i>p</i> -value	OR	95% CI	<i>p</i> -value		
Changes position (7)	Ref.			Ref.				
Moves within position (5–6)	2.62	1.8	3.82	<0.001	1.5	1.02	2.21	0.04
Maintains position (3–4)	3.45	1.9	6.27	<0.001	3.22	1.87	5.55	<0.001
Cannot maintain position (1–2)	7.79	2.19	27.73	0.002	4.15	2.3	7.48	<0.001
Female sex	1.24	1.01	1.52	0.036	1.14	0.94	1.38	0.178
Age	1.07	1.05	1.1	<0.001	1.05	1.03	1.07	<0.001
GMFCS I	Ref.			Ref.				
GMFCS II	2.79	2.15	3.62	<0.001	2.42	1.9	3.08	<0.001
GMFCS III	5.48	4.09	7.35	<0.001	3.32	2.42	4.54	<0.001
GMFCS IV	11.62	8	16.9	<0.001	7.17	4.53	11.36	<0.001
GMFCS V	27.82	14.49	53.43	<0.001	19.34	9.22	40.59	<0.001

PPAS: Posture and Postural Ability Scale. Ability to move into and out of position independently in supine or sitting, Gross Motor Function Classification System (GMFCS) level I and being male were used as reference categories. Age was used as a continuous variable. All variables were adjusted for all other variables in the model.



**Figure 1.** Simple logistic regression analyses with odds ratios (ORs) and 95% confidence intervals for pain in children with mild to severe postural asymmetries and inability to change position (postural ability). (A) Asymmetries in supine frontal view; (B) asymmetries in supine sagittal view; (C) asymmetries in sitting frontal view; (D) asymmetries in sitting sagittal view.

1.05–1.10]) and in sitting (OR 1.05 [95% CI 1.03–1.07]), even when adjusted for ability to change position, sex, and GMFCS level (Table 2). Furthermore, boys were found to have a slightly greater tendency to have postural asymmetries in supine than girls (Table 2).

### Postural asymmetries and pain

Pain prevalence was reported by 1,036/2,640 (39.2%) children (missing data  $n=95$ ). Pain was self-reported by 45.2% ( $n=1,237$ ) of the children and proxy reported by 52.8% ( $n=1,444$ ; missing data  $n=54$ ). Severe asymmetries in supine and sitting positions increased the risk for pain (OR 2.1–2.7) (Figure 1). There was also higher ORs for pain in children unable to change position (1.5–2.3) and with higher age OR 1.08 (95% CI 1.06–1.10).

### Postural asymmetries and ability to change position

In total, 824 (30.1%) children were unable to move independently in and out of a supine position and 995 (36.4%) in sitting. A clear majority of the children that were unable to change position also had an asymmetric posture in supine (760/824) and in sitting (919/995) (Table 3). Inability to change position doubled the probability of having postural asymmetries; in supine, OR (95% CI): frontal 2.0 (1.3–3.1), sagittal 1.9 (1.1–3.2); in sitting, OR (95% CI): frontal 2.5 (1.6–3.9); sagittal 2.8 (1.8–4.2), even when adjusted for age, sex and GMFCS level (Table 2).

### Postural asymmetries and GMFCS level

Postural asymmetries were seen in children at all GMFCS levels, with a strong negative correlation between GMFCS level and the

Table 3. Postural asymmetries relative to postural ability in supine and sitting.

Postural Ability	Sagittal				Frontal				Total	
	Full Symmetry 6 points		Postural Asymmetry 0–5 points		Full Symmetry 6 points		Postural Asymmetry 0–5 points		n	%
	n	%	n	%	n	%	n	%		
Supine										
Cannot maintain position (1–2)	3	0.2	98	7.7	3	0.2	98	8.1	101	3.7
Maintains position (3–4)	25	1.7	306	24.1	28	1.8	303	25.1	331	12.1
Moves within position (5–6)	82	5.6	310	24.4	75	4.9	317	26.3	392	14.4
Changes position (7)	1348	92.5	555	43.7	1414	93	489	40.5	1903	69.8
Total	1458	100	1269	100	1520	100	1207	100	2727	100
Sitting										
Cannot maintain position (1–2)	38	2.9	549	39.1	44	3.1	543	41.2	587	21.6
Maintains position (3–4)	20	1.5	144	10.3	28	2	136	10.3	164	6
Moves within position (5–6)	72	5.5	172	12.3	90	6.4	154	11.7	244	9
Changes position (7)	1182	90.1	539	38.4	1236	88.4	485	36.8	1721	63.4
Total	1312	100	1404	100	1398	100	1318	100	2716	100

total score of posture ( $r_s$   $-0.65$  to  $-0.68$ ) as well as their ability to change position in supine ( $r_s$   $-0.79$ ) and in sitting ( $r_s$   $-0.85$ ), indicating more asymmetries at increasing levels of functional limitations and need for the use of mobility devices. Children at GMFCS levels I–II more frequently had symmetric postures or mild asymmetries, whilst those at GMFCS level III showed mild to moderate, GMFCS level IV moderate, and GMFCS V severe postural asymmetries in both supine and sitting (Table 1). The most common asymmetry in supine lying was located at the upper and lower extremities for children at GMFCS levels I–IV and to the head and trunk for children with GMFCS level V (Table 4), while postural asymmetries in sitting particularly involved the trunk, pelvis, and weight distribution for children at GMFCS levels I–IV and the whole body from the head to the feet for children with GMFCS level V (Table 4).

## Discussion

This study reports on the prevalence of postural asymmetries, postural ability and pain in a large population of Swedish children with CP. To our knowledge, this is the first study exploring postural asymmetries and postural ability in children with CP. In this cross-sectional study of 2,735 children with CP at all GMFCS levels, postural asymmetries were observed in just over half of the cohort (60.2% sitting; 53.6% supine), and were evident in sitting and supine, in both sagittal and frontal planes. There were differences in the presence of postural asymmetries found in relation to gross motor function at all levels, and in relation to sex, boys had an increased risk of asymmetry (24%) solely in the supine position.

Consistent with previous findings in adults [4] a clear association was found between gross motor function and the presence of postural asymmetries. Specifically, as children's gross motor function decreased, the presence of postural asymmetries increased. For those with GMFCS level V these postural asymmetries tended to be more severe in both sitting and supine than for the other groups. The results support Ágústsson et al. [7] who also reported finding more postural asymmetries in adults with lower levels of motor function.

Several studies have reported postural asymmetries and deformities in adults with CP [4,11,12,20]. We found that the risk for postural asymmetries increased with age (OR 1.05 and 1.07 per year) in both supine and sitting. Nevertheless, we identified postural asymmetries also in the youngest children. This is consistent with findings by Fulford and Brown [27] and Porter et al. [6] and may indicate that postural asymmetries may originate early in childhood. The results support the need for early postural

interventions to monitor range of motion (ROM) and the development of postural asymmetries from an early age, and continuously throughout life [4,27]. The presence of postural asymmetries remains a concern, as previous studies have reported how they most likely result in soft tissue adaption, contractures, further postural deformities [4,7,12,20] and pain [28]. These changes may in turn lead to reduced functional participation [29] and decreased quality of life [30,31].

Postural asymmetries in sitting were more frequent than in supine lying and most commonly affected the trunk and pelvis, whereas in supine they more frequently involved the upper and lower extremities. Possibly, having more asymmetries in sitting may be a result of gravity having greater impact when trying to maintain a stable sitting position over a smaller base of support compared to maintaining symmetry in lying. Although this may not be the whole reason as Rodby-Bousquet et al. [4] reported more postural asymmetries in sitting compared with standing which has an even smaller base of support. Children with GMFCS level IV and V have more severe asymmetries affecting the whole body. Indeed, they may require postural support for several body segments to facilitate a more neutral postural alignment such as a spinal orthosis, and adequate supports within the wheelchair, seating system and in bed.

The postural asymmetries identified in children with GMFCS levels I and II most commonly affect only one or two body segments such as the feet or arms. This group of children can independently change position and subsequently are less likely to develop severe fixed deformities. However, clinicians could consider orthotics for the upper extremities or ankle-foot orthosis to facilitate biomechanical alignment and activities in everyday life. For all children, it is vital that any intervention does not negatively impact upon their ability to participate in everyday life.

The inability to change position increased the risk of having postural asymmetries in both sitting and lying, and with pain. Indeed, children unable to change position when in supine or when sitting were twice as likely to have severe postural asymmetries than those able to change position independently. This is concerning as this lack of ability to change position coupled with the amount of time spent in that position is reported to possibly result in an escalation of these postural asymmetries [4], and the risk of potentially life-threatening complications, reducing ability to participate in everyday activities and worsening quality of life [32].

Since just over 50% of children with moderate and severe postural asymmetries (56% frontal; 51.5% sagittal) required support to achieve an aligned sitting posture, adaptive seating systems may be a vital provision for these children to provide them with

**Table 4.** Distribution of postural asymmetries according to the Posture and Postural Ability Scale (PPAS) in Supine and Sitting for children at each level of the Gross Motor Function Classification System (GMFCS).

	GMFCS I		GMFCS II		GMFCS III		GMFCS IV		GMFCS V		Total n
	n	%	n	%	n	%	n	%	n	%	
<b>Supine</b>											
<i>Frontal</i>											
Head not midline	25	6.5	20	5.2	23	5.9	88	22.9	228	59.4	384
Trunk asymmetrical	35	8.3	33	7.8	32	7.6	108	25.6	214	50.7	422
Pelvis not neutral	32	6.3	41	8.1	52	10.2	150	29.5	233	45.9	508
Legs not separated	47	5.9	68	8.5	104	13	245	30.7	333	41.8	797
Arms not resting	71	9.5	63	8.4	55	7.4	228	30.6	329	44.1	746
Uneven weight distribution	34	5.6	56	9.2	69	11.3	182	29.8	269	44.1	610
<i>Sagittal</i>											
Head not midline	6	2.4	6	2.4	8	3.3	58	23.8	166	68	244
Trunk not neutral	10	3.6	14	5	13	4.6	82	29.1	162	57.7	281
Pelvis not neutral	32	6.3	46	9.2	52	10.3	150	29.9	222	44.2	502
Legs not straight	57	6.4	86	9.8	118	13.4	292	33.2	327	37.2	880
Feet not neutral	124	13.1	106	11.2	116	12.3	262	27.8	335	35.5	943
Uneven weight distribution	29	4.8	47	7.7	73	12	190	31.3	268	44.2	607
<b>Sitting</b>											
<i>Frontal</i>											
Head not midline	40	6.7	42	7.1	43	7.3	172	29	296	49.9	593
Trunk asymmetrical	89	12.2	80	10.9	81	11.1	205	28	277	37.8	732
Pelvis not neutral	62	9.9	70	11.2	73	11.6	176	28.1	246	39.2	627
Legs not separated	16	3.9	25	6.1	53	13	109	26.7	205	50.2	408
Arms not resting	68	10.1	53	7.9	53	7.9	205	30.4	295	43.8	674
Uneven weight distribution	89	12	94	12.7	80	10.8	199	26.8	281	37.8	743
<i>Sagittal</i>											
Head not midline	83	9.3	88	9.8	103	11.4	273	30.4	349	39	896
Trunk not neutral	102	11.3	102	11.3	114	12.6	278	30.8	306	33.9	902
Pelvis not neutral	119	12.9	116	12.6	126	13.7	259	28.1	302	32.8	922
Hips not flexed 90	10	4.2	19	8	37	15.6	57	24.1	114	48.1	237
Knees not flexed 90	2	1.1	7	3.8	19	10.4	48	26.4	106	58.2	182
Feet not neutral	88	13	77	11.4	70	10.4	193	28.6	247	36.6	675

stability and enable them to participate in activities of daily life. This is echoed in earlier work by Sahinoglu et al. [33] who found that both adjustable seating and custom molded seating was required for the children with more postural asymmetries, and Neilson et al. [34] who reported on improved quality of life and sitting posture through the provision of customized seating for adults with profound postural disabilities. Furthermore, the use of spinal orthoses may improve head control, stability, and arm--hand function of children with CP [35] and ultimately promote participation in activity and reduce pain [36].

The prevalence of pain was reported by 39% of the children and/or their caregivers in this study, similar to Aliksson-Smidt and Hägglund [9], who found that approximately one third of Swedish children with CP aged 1–14 years had pain, and that the occurrence of pain increased with age. In contrast, however, Parkinson et al. [29] reported that the prevalence of pain was 74% in their sample of 13–17 year olds. Further, we found a strong association between pain and postural asymmetries, with children with severe postural asymmetries being twice as likely to have pain as any other children. It is vital that pain is addressed possibly through the prevention or management of postural asymmetries, as it is well recognized that pain has a negative impact on both quality of life [18,30,37] and participation in activities of daily living [14,17,29]. Further studies are required to determine optimum postural interventions to pre-emptively manage pain for these children.

### Limitations

The cross-sectional design of this study means that all measurements reflect only a single time point, albeit the most recent for each participant. Although this design does not look at how

postural asymmetries develop or evolve over time, it does suggest that postural asymmetries can be identified already in children as young as 0–3 years of age, and a trend toward there being more children having postural asymmetries in the older age-groups, as well as the presence of pain. Although a strong agreement in pain prevalence rating between the young person and their proxy has been reported [8], assessment of pain is a challenge especially in children at a low age and in children with less efficient communication. Therefore, we decided to only include pain prevalence and defined any current pain reported by the child or proxy as having pain. This study did not explore whether the pain was acute or chronic in nature, the origin, severity or location of the reported pain.

### Generalizability

This large sample study reports on prospectively collected data of a large population of Swedish children with CP as registered in the Swedish CPUP registry. In Sweden, there is a proactive approach to healthcare delivery and generally utilization of 24-h postural management aiming to monitor and prevent postural asymmetry and contractures before they occur, and specifically on preventing hip dislocations in children [10]. Hence, these results may be slightly different from those in countries which tend to be more reactive in the management of posture and postural asymmetry in children with CP. Nonetheless, this study serves to highlight the importance of regular monitoring of children to permit early identification of postural asymmetries and subsequent treatment to ameliorate or prevent deterioration.



## Conclusions

In conclusion, in this population-based study 60.2% of children with CP had postural asymmetries in sitting, and 53% in supine, while 39.2% were reported to have current pain. Postural asymmetries increased as age increased, and gross motor function decreased. Children with severe postural asymmetries in either sitting or supine position were twice as likely to have pain and children unable to change position in supine were twice as likely to have postural asymmetries. Future research should explore any relationship between distribution of postural asymmetries and pain, as well as the effectiveness of postural management interventions in managing postural asymmetries of children with cerebral palsy.

## Disclosure statement

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## ORCID

Jackie Casey  <http://orcid.org/0000-0001-9408-9293>  
 Andreas Rosenblad  <http://orcid.org/0000-0003-3691-8326>  
 Elisabet Rodby-Bousquet  <http://orcid.org/0000-0001-8373-1017>

## Availability of data and material

The dataset analyzed during the current study is part of the CPUP registry.

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