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Patterns of postural asymmetry in infants: a standardized video-based analysis

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Abstract Cervical rotation deficit (CRD) and trunk convexity (TC) constitute the diagnosis of infantile postural asymmetry (IPA), which is often associated with further asymmetric features. However, very little data on the entire symptom complex are currently available. The aim of this study was to analyse the entire clinical spectrum of IPA based on a standardized video documentation. Forty-five infants (27 male) with an asymmetry score of ≥12 points (scale: 4–24) at a median post-term age of 10 weeks (range: 6–16) were selected from two previously studies using predefined criteria. CRD and TC as reactive movements to an orienting head turn in the prone and supine position were assessed from video recordings by three independent observers. Plagiocephaly, oblique body position and asymmetric foot position were descriptively assessed by consent of the same observers. Hip dysplasia data were derived from sonography charts. The assessment of the reactive movements showed a "scoliosis" pattern in six infants, a "torticollis" pattern in nine infants, a "mixed prone" pattern in 13 infants and a "mixed" pattern in 26 infants. Side agreement in the prone and supine position of TC and CRD was seen in 27 infants, with a left-sided convexity and left-sided head rotation deficit in two-thirds of the infants. Plagiocephaly was present in 27 infants, oblique body position in 13 infants, hip dysplasia in 4 infants and calcaneus foot in 11 infants. In conclusion, infantile asymmetry pattern analysis showed that morphological and functional anomalies are intricately linked and that infants with only a single apparent sign of asymmetry have actually a much more generalized disturbance.

Keywords Asymmetry · Plagiocephaly · Torticollis · Scoliosis · Posture · Infancy

Abbreviations CRD: Cervical rotation deficit · IPA: Infantile postural asymmetry · TC: Trunk convexity · TSC: Total score difference

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Introduction

In infancy, muscular imbalance, unilateral neuronal dysfunction, and asymmetric skeletal disturbances may lead to asymmetric features [2, 5, 6, 15, 25, 32, 33, 35]. If causes such as neuromuscular disease, cerebral infarction, plexus paresis, hemivertebrae, or intraspinal tumours are ruled out, the asymmetry will be defined as idiopathic and postural which is the most common type of infantile asymmetry [3, 6, 25]. Depending on the prominent feature of the asymmetry, a diagnosis of either plagiocephaly, torticollis, scoliosis, hip dysplasia or foot malposition is made, and a monosymptomatic therapy is instituted which, in many cases, neglects additional asymmetric features [4, 8–10, 23, 36]. In spite of this and probably in the face of the "Back to sleep" campaign for SID prevention and its presumably negative influence on postural development, an increasing number of studies address the entire symptom complex using names such as "moulded baby syndrome", "seven sign syndrome", "turned head-adducted hip-truncal curvature syndrome", "positional preference" or "infantile postural asymmetry" [5, 10, 15, 21, 22, 27, 29]. However, none of these studies has quantitated the intricate morphological and functional relationship of the anomalies constituting the asymmetric feature spectrum. We report here a standardized video-based analysis of asymmetry patterns in infants with infantile postural asymmetry which is defined as the coincidence of cervical rotation deficit and trunk convexity [27].

Methods

Probands From March 1999 through June 2001, 51 infants were referred to the out-patient clinic of the University Children's Hospital Mainz, Germany from three different paediatric practices for participation in a study for the development of an asymmetry scale [27]. The paediatricians were asked to refer infants with three different movement patterns – symmetric, slightly asymmetric and asymmetric – in whom the clinical course (progressive or resolving) was uncertain. From March through to December 2002, 61 infants were referred from 19 paediatric practices in Mainz to participate in a therapeutic randomized trial evaluating the effect of osteopathic treatment on infantile postural asymmetry. The paediatricians were asked to refer infants with a distinct asymmetric posture which had to be treated in their opinion. For the present video-based pattern analysis, 54 infants (27 male) at a median post-term age of 10 weeks (range: 6–16 weeks) were selected from both collectives according the following eligibility criteria: (1) video-based asymmetry score of ≥12 (mean of three independent observers); (2) gestational age ≥36 weeks; (3) absence of a neurological disease, notably hemiplegia, at outset and at 10–12 months of life; (4) a prompt orienting response to optic and acoustic stimuli. For the evaluation of the cervical lateral flexion, another eight infants (5 male) with an asymmetry score <12 points were selected from the first study collective.

All parents provided written informed consent, and the study protocol was approved by the Ethical Board of the Johannes Gutenberg-University of Mainz.

Procedures A full medical history was obtained, the infants were neurologically and physically examined by a paediatric neurologist and a physiotherapist and a standardized video of the infants in the prone and supine position was recorded [27]. All infants were properly screened for a traumatic lesion of the sternocleidomastoid muscle, but none was identified. For asymmetry pattern analysis, data which fit in the asymmetry framework were extracted from both collectives. In detail, information on intrauterine position and from hip sonography was obtained from the medical records. The neurological examination included the evaluation of spontaneous movements, orientation responses, positional reactions and reflexology according to Vojta [2, 12, 35].The results of the hand and foot grasp reflexes as indicators of asymmetric central nervous motor control and the results of the eye movement examination were included in the analysis. For the video documentation, the infant, together with a physiotherapist, was placed supine and prone on a prewarmed mattress with the video camera positioned above them at a distance of 2 m (Fig. 1).

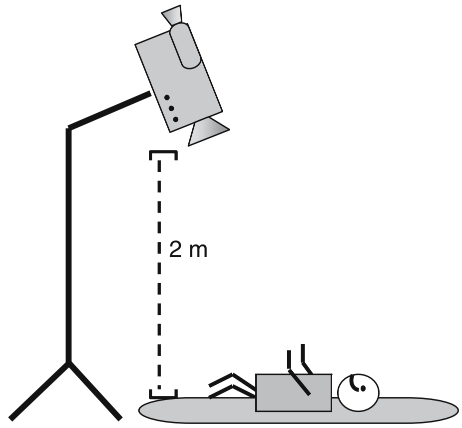


Fig. 1 Setting of video recording

Recording commenced with the infant's head being held for a brief period of time in the middle supine position. A head turn was then induced by presenting noises, toys or the physiotherapist's face, and moving them from one side to the other. After at least two turns to each side, the infant was put in the prone position with its head held for a brief time in the middle prone position, and the same procedures were repeated. Cervical rotation deficit and trunk convexity were assessed from video recordings by three independent, trained observers [27]. For each item, "trunk convexity supine", "trunk convexity prone", "cervical rotation deficit supine" and "cervical rotation deficit prone", points (range: 1–6) with precise descriptions were assigned (Figs. 2, 3). The composition of the asymmetry scale ensures that higher scores reflect a higher degree of fixation of the asymmetric feature (Fig. 3). Statistical analysis indicated good reliability and consistency of the asymmetry scale with an intraclass correlation coefficient of 91.5% (Cronbach alpha: 0.84).

Plagiocephaly, oblique body position and asymmetric foot position were assessed as descriptive categories from the videos by consent of the same observers. The descriptive categories for plagiocephaly are "left/right sided", "occipital/frontal", "focal" (only one cranial bone is affected) or "generalized" (most often parallelogram type). Oblique body position was defined as a preferential rotation pattern of the trunk to one side. Asymmetric foot position was present if one foot persisted in the calcaneus or adductus foot position throughout the orienting head turn to the right and left side while the position of the other foot changed. Finally, a

Supine					
	Trunk convexity	1	-	6	points
	Cervical rotation deficit	1	-	6	points
Prone					
	Trunk convexity	1	-	6	points
	Cervical rotation deficit	1	-	6	points
Total score		4	-	24	points
		symmetric	-	asymmetric	

Fig. 2 Composition of the asymmetry scale for infants at a post-term age of 6–16 weeks

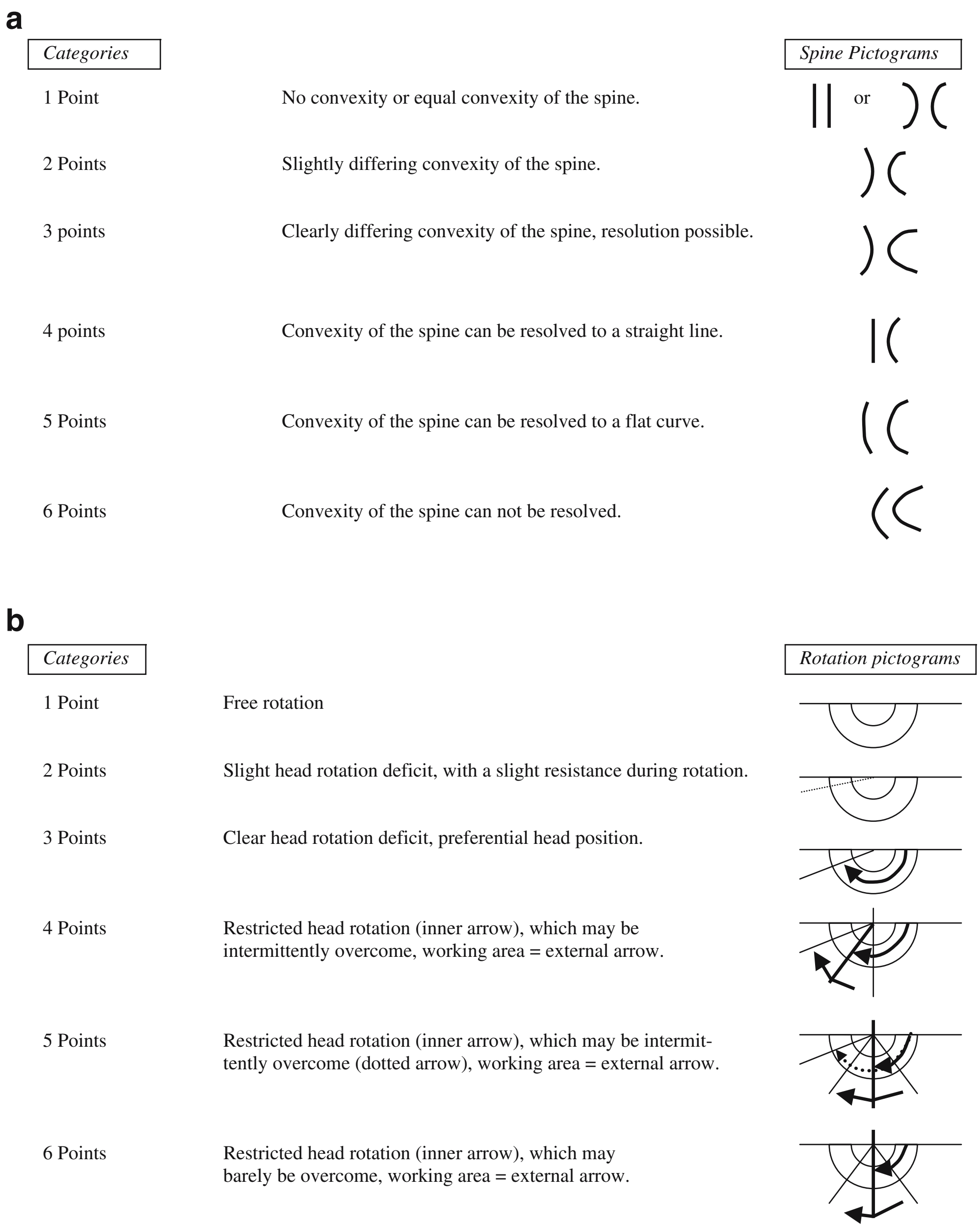


Fig. 3 **a** Definition of the six categories of trunk convexity. **b** Definition of the six categories of cervical rotation deficits

qualitative analysis of the cervical rotation and cervical lateral flexion was performed by consent of the observers.

Pattern definition A predominantly "scoliosis" or the "torticollis" pattern was assigned if the difference between the sum of trunk convexity prone and supine minus the sum of cervical rotation deficit prone and supine was ≥3 points. For assignment to the "mixed prone" pattern, the difference between the sum of both prone items and the sum of both supine items had to be ≥3 points. The 3-point level was chosen by consent of the three observers to be the minimal difference which led to the clinical impression that either a torticollis pattern or a scoliosis pattern was clinically leading.

Statistics The inter-observer-reliability of the asymmetry items was assessed using intraclass correlation. The relationships among the asymmetry items were evaluated by the *t*-test.

Results

The mean of the three raters of cervical rotation deficit and trunk convexity in the prone and supine position are presented in Fig. 4. Six infants showed a "scoliosis" pattern, nine infants showed a "torticollis" pattern, 13 infants showed a "mixed prone" pattern and 26 infants showed a "mixed" pattern (Fig. 4). The intraclass correlation coefficient and the 95% confidence interval of the items are: 0.83 (0.76–0.90) for cervical rotation deficit supine, 0.68 (0.56–0.79) for trunk convexity supine, 0.78 (0.70–0.87) for

) = trunk convexity
☺ = cervical rotation deficit

1 point = no asymmetric feature *(pale background)*
to 6 points = distinct asymmetric feature *(dark background)*

* fixed cervical lateral flexion in the prone position
** fixed cervical lateral flexion in the prone and supine position

↑ predominant pattern

Scoliosis - Pattern (↑ predominant: supine (, prone ()

Proband	supine (	supine ☺	prone (	prone ☺
1	4	2	4	3
2*	4	2	4	3
3*	4	2	5	3
4	5	2	4	4
5**	5	4	6	4
6**	6	2	5	4

Torticollis - Pattern (↑ predominant: supine ☺, prone ☺)

Proband	supine (	supine ☺	prone (	prone ☺
7**	4	3	2	6
8	3	4	4	6
9	3	5	1	3
10*	4	5	3	6
11	3	5	4	6
12	3	6	3	5
13	3	6	5	5
14*	4	6	4	6
15	4	6	4	6

Mixed Prone Pattern (↑ predominant: prone (, prone ☺)

Proband	supine (	supine ☺	prone (	prone ☺
16	2	2	4	4
17	2	2	5	4
18	2	3	4	3
19	2	3	4	4
20*	3	2	4	6
21	3	3	4	5
22	3	3	5	5
23	3	4	5	5
24*	3	4	5	6
25	3	5	6	6
26**	4	3	4	6
27	4	3	5	5
28*	4	3	5	6

Mixed Pattern

Proband	supine (	supine ☺	prone (	prone ☺
29*	3	2	4	3
30*	3	3	2	5
30*	3	3	3	4
32	3	3	4	3
33	3	3	4	4
34	3	3	4	4
35*	3	3	4	4
36	3	3	4	4
37	3	4	4	3
38	3	4	4	4
39	3	4	4	4
40*	3	4	5	4
41	3	5	4	3
42	4	2	2	4
43	4	3	3	4
44**	4	3	4	3
45	4	3	4	3
46	4	4	3	3
47	4	4	3	3
48	4	4	4	3
49	4	4	4	4
50	4	4	4	5
51	4	5	3	4
52	4	5	4	5
53*	5	2	2	6
54	5	3	3	3

Fig. 4 Patterns of postural asymmetry: mean score results of three independent observers of trunk convexity and cervical rotation deficit in the prone and supine position

cervical rotation deficit prone and 0.79 (0.71–0.87) for trunk convexity prone.

Analysing cervical rotation, a characteristic pattern in the prone and the supine position, was identified in most of the infants. In the supine position in 49 of 54 infants (91%), head rotation was always combined with a cervical lateral flexion to the contralateral side (Fig. 5a). In the prone position in 36 of 54 (67%) infants, head rotation was always combined with a cervical lateral flexion to the ipsilateral side (Fig. 5b). The same pattern was seen in all eight infants from the first study collective without significant asymmetry (asymmetry score <12 points), indicating that this pattern is the physiological cervical rotation pattern in infants aged 6 to 12–16 weeks. In the prone position, 18 infants (see single asterisk in Fig. 4) showed a fixed cervical lateral flexion to the contralateral side during a head turn to either side (Fig. 6a). Only five of these infants had a fixed lateral flexion to the same direction in the supine position (n=3 right side, n=2 left side) (Fig. 6b), these infants are marked with a double asterisk in Fig. 4. In all 18 infants with a fixed cervical lateral flexion in the prone position, the side of lateral flexion corresponded to the intrauterine position. A right-sided cervical lateral flexion was present in infants with a right occiput anterior position in utero, and a left-sided cervical lateral flexion was present in infants with a left occiput anterior position. In total, 24/49 (49%) infants with a physiological rotation pattern in the supine position and 24/36 infants (72%) in the prone position showed a side difference in cervical lateral flexion. There was no correlation between cervical lateral flexion and cervical rotation. Fifteen infants (28%) were able to decrease their cervical rotation deficit at the expense of the degree of convexity (Fig. 7).

Twenty-seven infants (50%) had a deformational plagiocephaly, seven of them from the generalized type. The right and left occipital bone (14/13 infants, respectively) was equally affected. Four of these infants showed a strabism which resolved spontaneously at the age of 12 months.

a

b

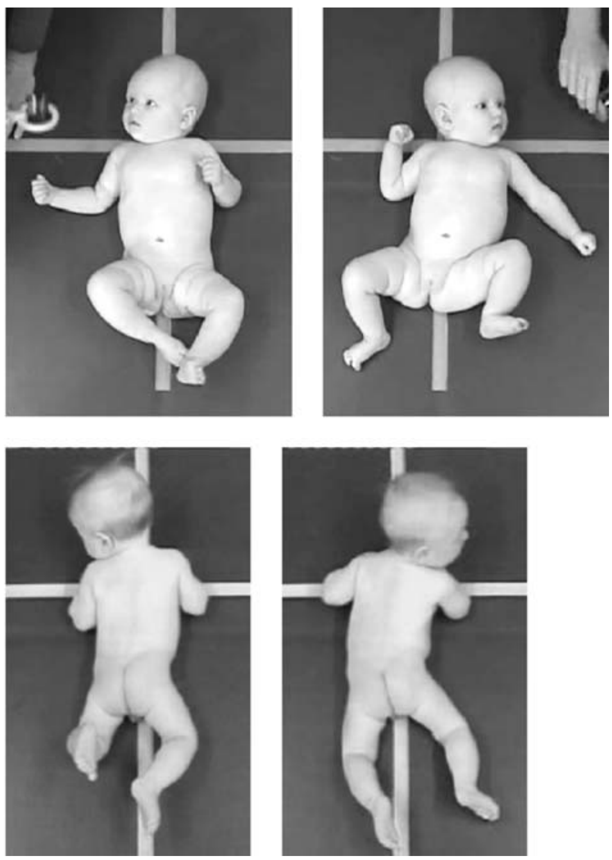


Fig. 5 Physiological pattern of head turning in the first months of life

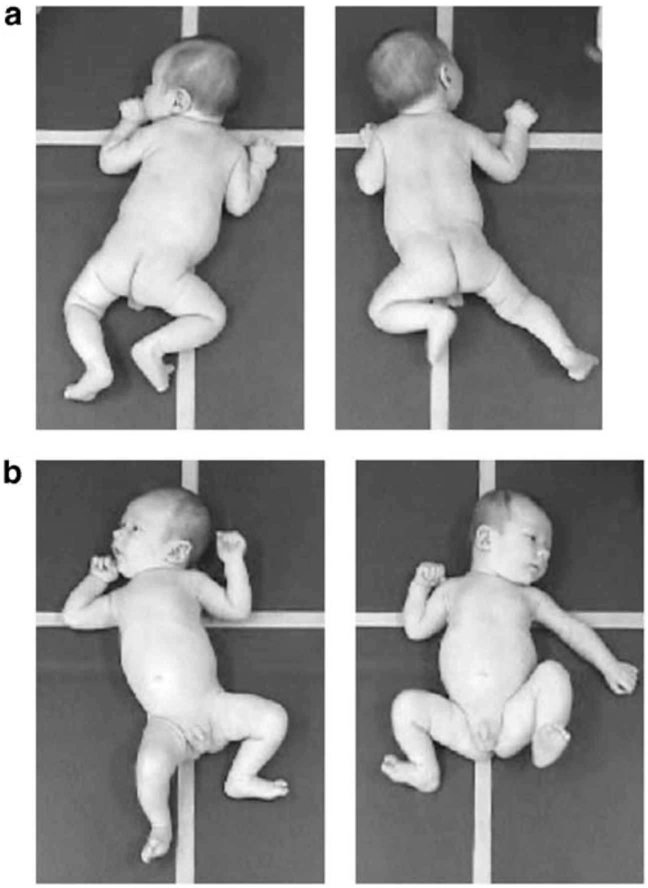


Fig. 6 Fixed cervical lateral flexion to the left side in the prone and supine position

An oblique body position was present in 13 of 54 infants (24%), and the side of preferential trunk rotation corresponded with the side of the affected occipital bone. An unilateral calcaneus foot position was registered in 11 infants, and an unilateral adductus foot position was registered in one infant. In six of these infants an oblique body position was present with a predominantly left calcaneus foot position and right-sided oblique body position pattern. Asymmetric foot position and oblique body position were positively related (p=0.017). Of 54 infants, four (7%) showed a unilateral hip dysplasia Type II c-g according to Graf [13].

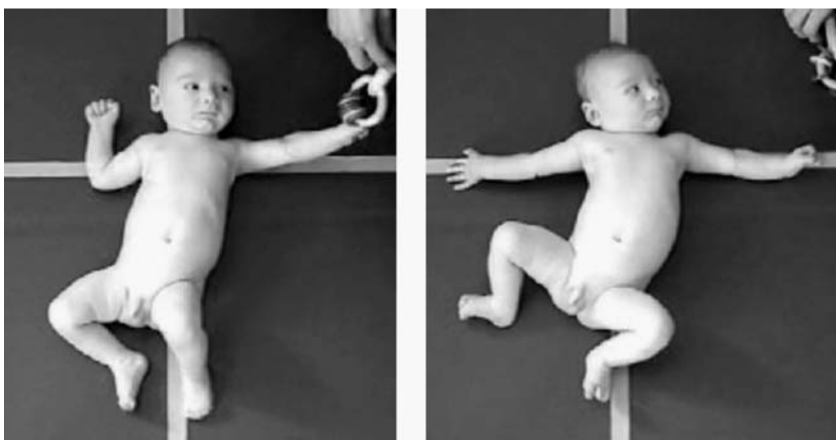
Evaluation of the side preference of the asymmetric features showed a side agreement of trunk convexity in the prone and supine position in 29 of the 54 infants (54%) and a side agreement of cervical rotation deficit in both positions in 25 of the 54 infants (46%). Two-thirds of these congruent infants showed a left-sided convexity (18 infants) and/or a left-sided cervical rotation deficit (17 infants). No further association between side preference of trunk convexity, cervical lateral flexion and cervical rotation deficit in either the prone or in the supine position was detected.

In 19 infants, the right hand reflex, and in five infants the left hand grasp reflex was unilaterally more intensive. In 50% of these infants (n=12), a concomitant increase of the foot grasp reflex was observed on the same or opposite side. Three infants showed a side different foot grasp reflex with a bilateral symmetric hand grasp reflex. An increased foot grasp reflex on the left side correlated with a left-sided cervical rotation deficit in the prone position (p=0.013).

Discussion

Our data show that infantile postural asymmetry quite commonly has multiple functional and morphological manifestations which may be focally accentuated. These manifestations have to be considered in the planning and evaluation of diagnostic procedures and therapy. The management of infantile asymmetry should be kept in the hands of the paediatrician who initiates conservative treatment and refers the infant to specialists for the treatment of focally aggravated symptoms. If started early, conservative approaches that involve putting the infant in the prone position while awake, feeding from both sides and handling have been shown to be promising [1, 2–5, 11, 16, 17, 19, 34]. These are useful approaches to forestall the development of plagiocephaly and ensuing temporomandibular joint displacement [31], strabism following frontal plagiocephaly with desagittalization of the tendon of the superior oblique eye muscle [7, 10], torticollis-related head immobility [4, 5, 9, 10] followed by asymmetric displacement of

Fig. 7 Reduction of cervical rotation deficit at the expense of an increase in trunk convexity



the occipital condyles and atlanto-occipital displacement [18] and subsequent progressive scoliosis [4, 9, 21, 23, 32], foot malpositions with gait disturbances resulting from oblique body position and hip asymmetry [3, 25, 36]. These complications bear witness to the mutual dependence of, and interaction between, functional and morphological features characterizing infantile postural asymmetry. The complexity is further accentuated by changes in body position with time. As the sidedness of cervical rotation deficit and trunk convexity differs depending on the prone and supine position, postural changes will alter the degree of cervical rotation deficit and, consequently, trunk convexity. This, in turn, will lead to changes in the asymmetric foot position. Changes such as these may explain that the inter-observer reliability was higher for the entire asymmetry score than for each single item [27]. Another illustrative example for the mutual intensification between the individual asymmetric features is the clinical course of congenital muscular torticollis. After birth, the muscular torticollis with cervical lateral flexion to the side of the muscular damage and a head rotation to the contralateral side appears as a single asymmetric symptom. Only a few weeks later, a deformational plagiocephalus develops which is, after verticalization, followed by a double curved scoliosis with a thoracic convexity on the affected side in untreated cases [2, 10].

The left side predominance of trunk convexity and cervical rotation deficit in supine and prone congruent infants in our study group are in accordance with other reports [5, 21, 29]. However, a comparison is limited by a non-standardized clinical evaluation of the scoliosis and positional preference in these reports. The great pattern variation in the prone and supine position in our infants suggests a more complex regulation of postural asymmetry than previously thought.

Our qualitative analyses of cervical rotation revealed that during the first 4 months of life, head turn is physiologically associated with a contralateral cervical lateral flexion in the supine position and an ipsilateral cervical lateral flexion in the prone position. A cervical rotation deficit in the supine position thus points to a sternocleidomastoid and trapezial muscle dysfunction and/or a fixation in the C_1/C_2-joint, whereas a cervical rotation deficit in the prone position indicates a dysfunction of the autochthonous anterior and posterior cervical muscles and/or fixation in the C_2–C_7-joints [18, 26]. According to our data, cervical rotation deficit and asymmetric cervical lateral flexion seem to be independent of each other and, for the purpose of therapeutic goal definition, have to be documented separately. Cervical rotation deficit can be quantified using the asymmetry scale, whereas cervical lateral flexion can only be documented qualitatively at that same age group.

Our observation that the most severe examples of asymmetric cervical lateral flexion were correlated with the infantile intrauterine position supports the pathogenic concept of infantile postural asymmetry as a sequel of intrauterine constraint.

Although, in general, infants with postural asymmetry are considered to be neurologically healthy, the asymmetric hand and foot grasp reflexes found in some of our infants may be a hint for subtle neurological changes in these infants. Follow-up studies of children with infantile postural asymmetry will be of interest in view of the claim that infantile position preferences influence the development of perceptual and motor preferences by increasing visual orientation to the right side [14, 20, 24, 28, 30].

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