

DESCRIPTIVE REPORT

# Symptomatic asymmetry in very young infants: A Delphi study on the development of a screening instrument

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## ABSTRACT

The objective of this study was to develop a screening instrument for pediatric physiotherapists to distinguish a symptomatic asymmetry in the clinical evaluation of young infants (age <6 months) with an asymmetric head posture. We chose two consensus methods, a two-round Delphi design and an expert meeting using nominal group technique, for reaching agreement about classification of diagnoses and clinical diagnostic criteria (CDC). Seventeen diagnoses with an expression of asymmetry with 69 matching CDC were assessed. In two Delphi rounds, six medical specialists and seven pediatric physiotherapists were polled anonymously on the classification, completeness, and relevance of the diagnoses and the CDC. Panel consistency in round 2, expressed as Cronbach's- $\alpha$ , was 0.89. In round 3, a face-to-face meeting with eight therapists, the previously selected diagnoses and CDC were prioritised, reduced to 10 diagnoses and 21 CDC, and completed with eight hard clinical signs (red flags). Finally, a differential diagnostic screening instrument, containing a classification scheme, the CDC for differential diagnostics, and a list of "red flags" was established on the basis of literature search and expert consensus. Cross-validity and reliability of the instrument will be investigated in future research.

## INTRODUCTION

A nonphysiological idiopathic asymmetry in shape and/or posture of the head in young infants is an increasingly prevalent clinical condition that warrants careful examination in pediatric physiotherapy practice (Boere-Boonekamp and van der Linden-Kuiper, 2001; Persing, James, Swanson, and Kattwinkel, 2003; Van Vlimmeren, Helders, Van Adrichem, and

Engelbert, 2004; Van Vlimmeren et al, 2007). Physiologically, young infants may have an asymmetric posture due to the influence of the "asymmetric tonic neck reaction" and an unstable posture in the supine position in the first months of life. This asymmetry is bilaterally and nonobligatory (van Kranen-Mastenbroek et al, 1997). In contrast to physiological asymmetry, 12–17% of all newborns develop a positional preference during the first 6 months of life (Boere-Boonekamp and van der Linden-Kuiper, 2001; Boere-Boonekamp, Bunge-van Lent, Roovers, and Haasnoot-Smallegange, 2005; Van Vlimmeren et al, 2007). In the prevalence studies, a "positional preference" is defined as a condition in which the infant's head is turned toward one side most of the time and active movement to

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the other side is restricted. About a quarter of them are treated by pediatric physiotherapists (Boere-Boonekamp and van der Linden-Kuiper, 2001). A distinct positional preference of the head in the first weeks of life or a frequently seen distinct plagiocephaly at birth may secondarily cause any asymmetry in shape and/or function of the entire body. In this way, healthy and neurologically normal infants may develop a deformational plagiocephaly, a postural torticollis, or a postural scoliosis (Boere-Boonekamp and van der Linden-Kuiper, 2001; de Chalain and Park, 2005; Hutchison, Hutchison, Thompson, and Mitchell, 2004; Hutchison, Thompson, and Mitchell, 2003; Stellwagen, Hubbard, Chambers, and Jones, 2008; Van Vlimmeren et al, 2007). The high prevalence rate is related to the medical advice to put babies on their back to sleep to diminish the risk on “cot death” (de Jonge and Hoogenboezem, 2005; Kane, Mitchell, Craven, and Marsh, 1996; L’Hoir et al, 1998; Pollack, Losken, and Fasick, 1997). The etiology of this idiopathic asymmetry (IA) is unknown, but risk factors to develop a plagiocephaly in the first months of life are: male gender; first born; positional preference when sleeping; one-sided handling during diaper changing and bottle feeding; tummy time when awake less than three times per day; and slow achievement of motor milestones (Boere-Boonekamp and van der Linden-Kuiper, 2001; Hutchison, Hutchison, Thompson, and Mitchell, 2004; Hutchison, Thompson, and Mitchell, 2003; Kane, Mitchell, Craven, and Marsh, 1996; Peitsch, Keefer, LaBrie, and Mulliken, 2002; Van Vlimmeren et al, 2007).

Generally, this idiopathic asymmetry is a condition with a benign prognosis. On the other hand, an asymmetric head posture can sometimes be one of the symptoms of an underlying disorder, disease, or dysfunction, such as a malformation of the spine, a visual disfunction, or a tumor at the posterior fossa. Besides, abnormalities like developmental dysplasia of the hip are more often seen in infants with an asymmetric (head) posture. Timely recognition of such a symptomatic asymmetry (SA) is important with a view to treatment and/or prognosis (Ballock and Song, 1996; Bredenkamp, Hoover, Berke, and Shaw, 1990; Van Vlimmeren, Helders, Van Adrichem, and Engelbert, 2004). In the Dutch situation, well baby clinic physicians or general practitioners often refer young infants to pediatric physiotherapists for diagnostic reasons. Besides, parents have direct access to physiotherapists since 2006. In the current literature, a few algorithms about differential diagnostics of symptomatic asymmetry exist (Ballock and Song, 1996; Bredenkamp, Hoover, Berke, and Shaw, 1990; de Chalain and Park, 2005; Do, 2006; Van Vlimmeren, Helders, Van Adrichem, and Engelbert,

2004). These studies, however, have concentrated on the diagnostic process, rather than on a description of diagnostic criteria. In pediatric physiotherapy practice, the available diagnostic instruments regard asymmetry as a symptom of a central neurological disorder and are not comprehensive to all causes of symptomatic asymmetry.

A formalised screening process, based on the notion of pattern recognition, should precede the routine diagnostic process. Pattern recognition is defined in terms of an inductive reasoning process, particularly used in diagnostic reasoning by recognising a set of signs and symptoms (Higgs and Jones, 2000). The concept of so-called “red flags” is important (Greene, 2001). Red flags are “historical and clinical clues that may indicate the presence of a serious underlying disorder” (Arce, Sass, and bul-Khoudoud, 2001). Recognition of red flags in the diagnostic reasoning process avoids missing serious pathology. Given that a positional preference occurs in the first months of life, we chose to study differential diagnostic screening in infants under 6 months of age. An instrument for differential diagnostic screening will improve clinical decision making and increase the transparency of the diagnostic process. Such an instrument, originating from a biomedical view, contains diagnostic criteria, consisting of signs and symptoms in the domain of impairments in structure or function (Nuysink, van Haastert, Takken, and Helders, 2008).

The objective of the present study was to develop a screening instrument for pediatric physiotherapists to distinguish a symptomatic asymmetry in the clinical evaluation of young infants (<6 months of age) with an asymmetric head posture, based on literature search and expert validity.

## METHODS

### Design

This study, intended to develop a screening instrument with expert validity, had a qualitative design. Two consensus methods were chosen, which are useful in identifying and measuring matters of uncertainty in medical and health care: 1) a two-round Delphi design and 2) an expert meeting in round 3, using nominal group technique (Jones and Hunter, 1995) (Figure 1). The Delphi method and the nominal group technique are both considered suitable methods for reaching agreement among colleagues in a bottom-up process in issues like treatment or clinical reasoning protocols (Murphy et al, 1998). A combination of more than one method, called “method triangulation,” strengthens the validation process, just as the inclusion of expert groups

from a different professional background (source triangulation) (Carpenter and Hammell, 2000).

The Delphi method enables the participation of experts without the need to physically bring them together (Murphy et al, 1998). In this method, experts perform a survey independent of one another, but have the opportunity to revise their opinion during the process. They receive questionnaires in a first round and are invited to quantify their opinion and to give qualitative comments whenever they feel the need to. In the second round, they are provided with a summary of the results and are asked to reconsider their initial judgement regarding the results. The process can be continued until an acceptable degree of consensus is reached. The advantages of this method are low costs, controlled interaction, and easy access (Hasson, Keeney, and McKenna, 2000).

The purpose of a nominal group technique in an expert meeting is to give panelists the opportunity to discuss issues face-to-face, in the view of previous results and their own knowledge on the topic. A meeting is characterised by structured interaction, such as separated rounds of idea generation and/or clarification, argumentation, and voting (Jones and Hunter, 1995; Murphy et al, 1998).

## Preparation phase

### Classification

Many possible diagnoses were first classified by two investigators as idiopathic or symptomatic asymmetry, subsequently as localised or generalised, and “body parts involved.” The investigators have a more than 20 years’ experience with this health problem in primary care (JN) and in an academic hospital (IvH). Both are involved in the postgraduate master curriculum of pediatric physiotherapists. The disorders and diseases had been derived from four sources: 1) differential diagnostic schemes used in specialist education (Engelbert and van Vlimmeren, 2006; Essen, Sleijpen, and Crombag, 2004; Van Vlimmeren, Helders, Van Adrichem, and Engelbert, 2004); 2) key informant interviews with two researchers in “neonatology” and “asymmetry in infants,” respectively; 3) textbooks from the clinical specialties; and 4) peer-reviewed literature on the topic (Nuysink, van Haastert, Takken, and Helders, 2008).

### Clinical diagnostic criteria (CDC)

The list of preliminary CDC contained observations and manoeuvres (provocations, palpations, and measurements) performed during the first examination of the infant. These were clustered around possible diagnoses. To prepare this list, the same sources were

used as for the classification proposal. This list enclosed 12 sets of diagnoses with 69 matching CDC regarding symptomatic asymmetry within the musculoskeletal, neurological, and sensory domain. Five diagnoses in systems other than the musculoskeletal were appended to generate red flags. Five sets of CDC covering idiopathic asymmetry “diagnoses” completed the list.

In addition to the list of preliminary CDC, a list of red flags was composed after round 1, analogous to the CDC list (Nuysink, van Haastert, Takken, and Helders, 2008), including information derived from round 1.

Four research questions were formulated to investigate the experts’ opinion on the following topics:

- 1) Can both expert panels, medical specialists and pediatric physiotherapists, assent to the taxonomy and nomenclature of SA and IA?
- 2) Are the selected CDC correctly formulated, complete, and relevant?
- 3) Which clues are “hard” signs (so-called “red flags”)?
- 4) Is the established screening instrument a useful and efficient instrument for the evaluation of symptomatic asymmetry in infants up to 6 months of age by pediatric physiotherapists?

## Delphi method, round 1 and 2

The Delphi expert panel consisted of two groups: 1) ten medical specialists and 2) eight pediatric physiotherapists. The medical specialists were recruited from the clinical disciplines that are usually involved in the screening, diagnosis, and/or treatment of infants with different kinds of asymmetries. This panel included two well baby clinic physicians, two pediatricians and specialists from pediatric surgery, orofacial plastic surgery, child-neurology, orthopaedic surgery, otorhinolaryngology, and child-ophthalmology. They were selected on a convenience sample for pragmatic reasons (Arcury and Quandt, 1998). Eight of ten had an academic affiliation, and all were familiar with young infants with an asymmetric condition. An inclusion criterion was that candidate panelists were known to the investigators as interested in physiotherapy procedures regarding this health problem or were coauthors of scientific publications about the subject. The pediatric physiotherapist panelists were considered experts for different reasons: they were experienced clinical specialists working in a hospital or a private practice. In addition, they were lecturer in the clinical specialist master-education for pediatric physiotherapy or researcher and known as opinion leader in the professional field in the Netherlands (Jensen, Gwyer, and Shepard, 2000). All physiotherapy experts had more than 20 years’ experience. They were selected on a purposive sample for

strategic reasons (Arcury and Quandt, 1998). Both groups were recruited from all over the country.

The aim of round 1 was to classify a list of diagnoses and to refine and evaluate the CDC with regard to research question 1 and 2. The experts were invited to recommend additional diagnoses or CDC and to comment upon the definitions of the CDC. Panelists were then asked to value the signs, to establish the degree of relevance of each item as a clinical diagnostic criterion relating to the diagnosis (research question 2). A five-point scale with the anchors “completely irrelevant” (=1) and “extremely relevant” (=5) was used to record the responses. On this so-called “semantic differential” scale, only the extremes were labelled to give the respondents the opportunity to express their own thoughts about the criteria (Portney and Watkins, 2007). With regard to research question 3, the panelists were asked to name signs or symptoms they considered to be a “red flag.”

Round 2 was intended to obtain convergence in the ratings of round 1, supported by feedback of the group on the same questions. Panelists were asked to reconsider their own rating of the CDC. Research question 3 was adapted to determine the importance of red flags as potential alarming signs. To get more differentiation in the answers, a 10-point scale with the extremes “completely unimportant” (=1) to “very important, always examine” (=10) was used to indicate the importance of the red flags.

Prospective panelists were provided with an information package by electronic mail, containing a synopsis of the study plan and the Delphi procedure, an a priori classification scheme, and a matching list of CDC. Questionnaires were used in both rounds, which were sent by e-mail. The panelists were blinded for the other co-panelists.

## Expert meeting

In round 3, a different method and perspective were chosen. The reason for this change was to strengthen the consensus process, because argumentation in a face-to-face meeting is considered a valuable addition to the anonymous Delphi process (Murphy et al, 1998). The shift to the pediatric physiotherapy perspective had two objectives: 1) to refine the outcome of the Delphi rounds by the professionals who have to use the instrument in practice; and 2) to judge and answer to Research Question 4 in round 3: “Is the established instrument a useful and efficient instrument for the evaluation of symptomatic asymmetry by pediatric physiotherapists?”

The panel in round 3 consisted of eight pediatric physiotherapists. Three experts from the previous

Delphi rounds were willing to participate in a face-to-face panel. For different reasons, four experts were not able to participate any more: two because of the long travel distance to the meeting and two due to shortage of time. All four assumed that they had given all the input they wanted. Five new experts with comparable experience and knowledge about the subject were recruited. The mean number of years of experience in the panel was 26.8 years (SD 3.85).

Prior to the meeting, each panel member was provided with the questions of round 3, a summary of the results of round 2 regarding CDC and red flags, and the draft version of the instrument. One of the experts was panel chairman. The procedure of the nominal group technique during the meeting was as follows: first the project leader (JN) introduced every question with a short presentation; subsequently, the panelists could ask clarifying questions followed by an argumentation round. Finally, they expressed agreement by voting. The basic assumption of consensus during the expert meeting in round 3 was an agreement of six of eight on all (dichotomised) questions. In the case of 5/8, a second argumentation round should be followed by a weighted voting on a 1–9 scale (Fitch et al, 2001).

In round 3, the participants were asked to confirm the interpretation of the results from the first two Delphi-rounds to obtain consensus with regard to research question 1–3. In a face-to-face meeting, they discussed definitions and prioritisation. The expert meeting in round 3 was digitally recorded, and minutes were taken by one of the panelists and the project leader. All panelists had to give their consent to the report afterward. Finally, all panel members were asked to respond individually by e-mail to research question 4 presented as an open-ended question, about the usefulness of the screening instrument for pediatric physiotherapists. In Figure 1 the process and content of the rounds are shown.

## Data analysis

The CDC list and the red flags list were recorded in an MS Excel (Microsoft BV, Amsterdam, The Netherlands) spreadsheet. Descriptive analysis was performed for research questions 2 and 3, within and between the expert groups. The panelists were informed with regard to the mean, the median, range, and standard deviation (SD) scores as feedback for round 2. Decrease of the variance was interpreted as an increasing convergence. A mean and median score of  $\geq 4$  ( $SD < 0.7$ ) on the 5-point scale was considered as a relevant CDC, a score between 3 and 4 as doubtful, and a mean/median score  $\leq 3$  ( $SD > 1$ ) as irrelevant. With a mean score of  $\geq 8.5$  ( $SD < 1.3$ ) on

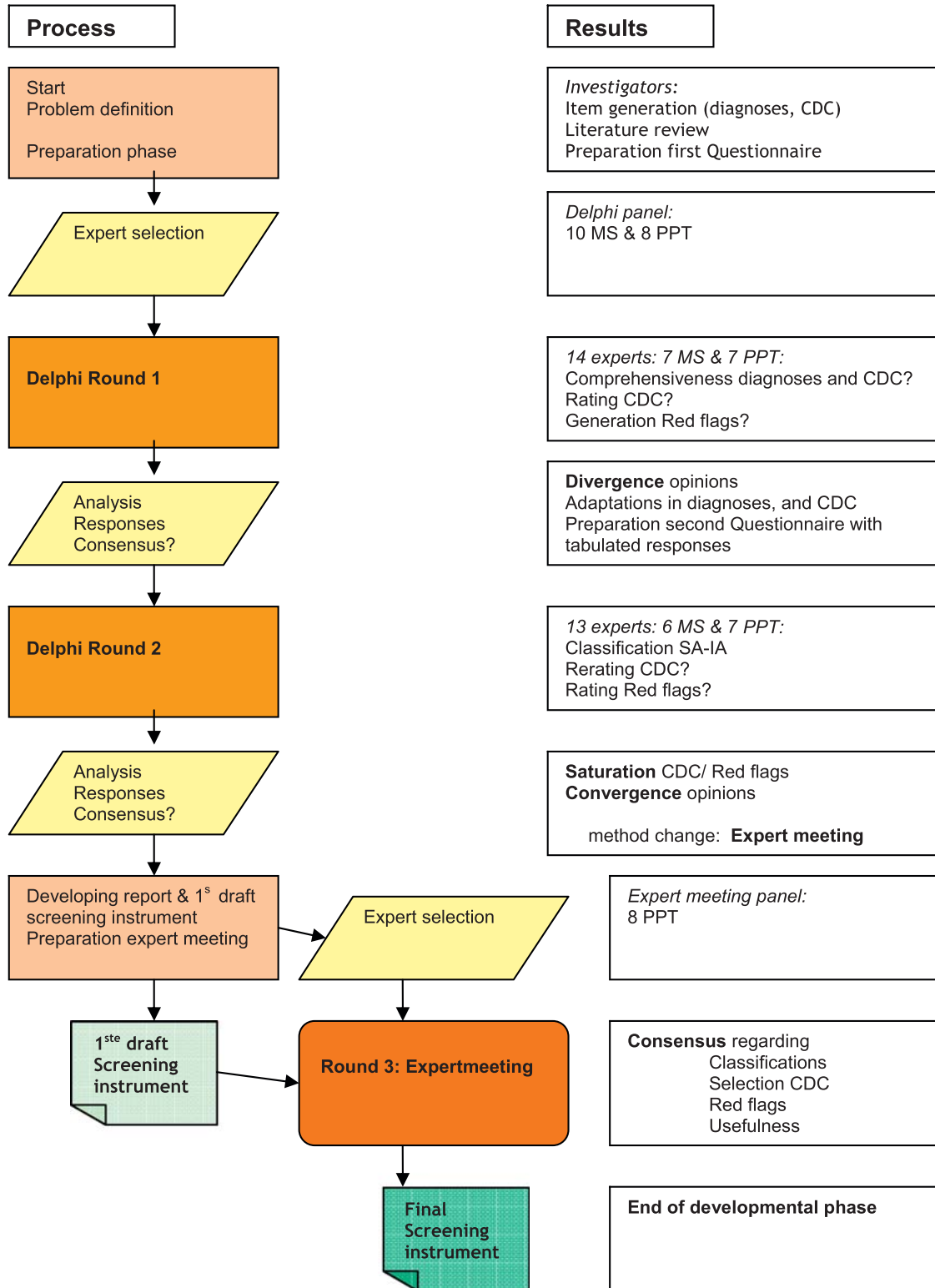


FIGURE 1 Flowchart of the consensus process of a differential diagnostic screening instrument to recognise symptomatic asymmetry. SA: symptomatic asymmetry; IA: idiopathic asymmetry; CDC: clinical diagnostic criteria; MS: medical specialists; PPT: pediatric physiotherapists.

the 10-point scale, a red flag was considered to be a hard clinical sign. The importance of the signs and

symptoms with a lower score were considered as “dependent on context variables.”

For this study, consensus within the Delphi group was defined as the homogeneity of the panel, as expressed in the consistency of opinion among the panelists. Cronbach's- $\alpha$  was used to quantify the reliability of the panelists' scores on the CDC list. For a scale to be useful in clinical practice when screening individual patients, Cronbach's- $\alpha$  should approach 0.90 (Bland and Altman, 1997; Portney and Watkins, 2007). The consistency within the panel was analysed, including the changes between rounds 1 and 2.

## RESULTS

### Round 1 and revisions

Seven of ten medical specialists and seven of eight pediatric physiotherapists returned the questionnaire in the initial round. Reminder e-mails or telephone calls were sent to the nonresponders or to panelists who did not complete the questionnaire. One physiotherapist withdrew her cooperation due to a lack of time. Eventually, three medical specialists, an orthopaedic surgeon, an otorhinolaryngologist, and a pediatric neurologist, did not respond to the several reminders. So, we do not have information about the reasons for their nonparticipation.

In general, classification as either SA or IA was thought to be appropriate and applicable for the health problem "asymmetry in infancy." Some rare SA diagnoses were mentioned. The description of some IA diagnoses (e.g., postural torticollis) was not as clear for the medical specialists as it was for the pediatric physiotherapists. IA diagnoses turned out to be a more or less description of symptoms, instead of clear medical diagnoses. Moreover, synonyms were used to describe the same feature, such as "Moulded baby" and "Turned-Adduction-Curvature syndrome." A few extra SA diagnoses (e.g., vascular ring), all with a very low incidence, were added to the scheme under the following collective terms: infections, intern causes, and anomalies (Table 1); two IA diagnoses were merged and the terminology was slightly adapted. The classification in "localised/generalised" and "body parts involved" was not considered to be appropriate. Instead, the use of the International Classification of Diseases (ICD), 10th version (World Health Organisation, 2007), was recommended to get a systemic taxonomy. Another suggestion was to list SA diagnoses in a declining order of incidence, so to streamline the differential diagnostic process. We decided to use the declining order for the screening instrument only and to list all possible SA causes in a separate classification scheme (Appendix 2). All diagnoses were classified according to the ICD-10.

The diagnoses were stratified by the time of the onset of asymmetry in ante-, peri-, or postpartum. Incidence data of diagnoses were derived from the literature (Nuysink, van Haastert, Takken, and Helders, 2008).

The panelists rated the CDC on the five-point scale. Not all the items involved were filled in by all participants. Especially the medical specialists from pediatric surgery, orofacial plastic surgery, and child-ophthalmology restricted their ratings to their own specialty. Medical specialists working in a general health care domain (Infant Healthcare Centre or pediatrics) and pediatric physiotherapists completed the document, but they occasionally skipped a single item they did not recognise. The median score of all CDC was 4 (range 1–5). The mean scale score of the CDC was 3.8 (SD $\pm$ 0.58); by medical specialists 3.65 (SD $\pm$ 0.68), by PPTs 3.98 (SD $\pm$ 0.66). On the diagnostic level, generally one or two CDC were rated 4 or more, but often with an SD >1.0. On the CDC level, a mean difference of more than 1 point was occasionally seen between the two panels, with a range from 1 to 5. The respondents used the opportunity to make remarks and corrections and to suggest additional criteria. They missed an age specification on some criteria and criteria derived from the intake. Some experts commented upon the meaning of relevancy (research question 2). Two physicians preferred the terms sensitivity and/or specificity.

In the second round the same format was used, but the CDC were slightly revised. One revision was the age appropriateness of some criteria. Four new CDC were added and two skipped, as suggested by the orofacial plastic surgeon and the child-ophthalmologist. The survey included the frequency distribution on each item of the round 1 response (mean, SD, median, range) for the total group of experts as well as for both panels separately. The CDC with a mean score of  $\geq 4$  were highlighted, being the most relevant signs. To get a maximum response on the most relevant CDC, experts were encouraged to rate at least the highlighted items, if they had not enough time to complete the document.

The revised survey, containing 16 SA diagnoses (with 64 CDC and 15 red flags) and 6 IA diagnoses (with 41 CDC), was sent by e-mail to all 14 respondents together with a report of the results and conclusions. The aim for the next round was to realise enough convergence in the ratings to enable data reduction (Figure 1). The results are presented in Table 1.

### Round 2 and revisions

Thirteen participants (6 medical specialists and 7 pediatric physiotherapists) completed round 2. For unknown reasons, the pediatric surgeon did not

TABLE 1 Additions to and modifications of symptomatic asymmetry diagnoses and clinical diagnostic criteria

Diagnoses	Start ΔR1	Start ΔR2	Start expert meeting	Final order of rank most
	Preliminary CDC	Changes CDC/RFL	Order of rank selected SA diagnoses RFL	prevalent SA diagnoses RFL
<b>Symptomatic asymmetry</b>				
1	Developmental dysplasia of the hip	5 CDC	1	1
2	Facial Palsy	7 CDC	-1 +1	8 X
3	Ocular disorder	9 CDC	3 adapted	4
4	Hearing disorder	4 CDC	+1 1 adapted	11 9
5	Malformation cervical spine	4 CDC		6
6	Malformation thoracic/lumbar spine	5 CDC		7
7	Craniosynostosis	4 CDC	-1 +2 2 adapted	9 8
8	Syndrome	-	+1	10
9	Perinatal fracture clavicle	4 CDC		2
10	Congenital muscular torticollis	9 CDC	X → IA	- 4 Added from IA
11	Obstetric brachial plexus palsy	10 CDC		3
12	Central nervous system disorder	8 CDC		5 6
13	Infections	-		
14	Osteomyelitis, Juvenile Idiopathic Arthritis	-		6 abs RFL 8 abs RFL
15	Intern causes	-	15 pot RFL	9 rel RFL 7 rel RFL
16	Tumor	-		
17	Trauma	-		
	Anomalies non-musculoskeletal (added Round 2)	-		
<b>Idiopathic asymmetry</b>				
	Plagiocephaly only			
	Postural torticollis			
	Postural scoliosis			
	Turning-adduction-curvature syndrome		Merged	
	Moulded baby			
	Cervical spine impairment e.c.i	-	Added	
	Congenital muscular torticollis	-	Added from SA	→ SA

Legenda: CDC= clinical diagnostic criteria; RFL= red flags; ΔR= Delphi Round; SA= symptomatic asymmetry; IA= idiopathic asymmetry; -= absent; X= discarded; → = shifted from group; pot= potential; abs= absolutely important; rel= relatively important; e.c.i.= e causa ignota.

respond. The panelists agreed with the revised classification scheme, but a few new suggestions for the nomenclature were given (e.g., to use the term “developmental dysplasia of the hip” instead of “congenital dysplasia of the hip”). Based on these recommendations, minor changes were made in the

classification scheme. A selection of the 10 most frequent occurring SA diagnoses could be established for a draft version of the instrument.

The rating of relevance of the CDC showed less divergence between the panelists than in round 1. These CDC were mainly the same as those identified in

round 1, yet with a mean SD of 0.72. Many CDC got a score of  $\leq 3$  ( $SD > 1$ ) and as such were considered irrelevant. In four SA diagnoses, two CDC could be distinguished, according to the a priori criterion for item reduction ( $\geq 4$ ;  $SD < 0.7$ ). In another four diagnoses only one CDC could be included. A second CDC was selected with an  $SD > 0.7$  and  $< 1.0$ . In Table 3, the mean, median, range, and SD of the selected CDC, as well as the change between the rounds are presented. In two diagnoses (craniosynostosis and congenital malformations), the choice of CDC was disputable for different reasons. No CDC concerning craniosynostosis met the inclusion criteria. One of the experts, the plastic surgeon who is expert at the topic, advised two new CDC in round 1, as is mentioned before. In round 2, one of these criteria, “downward sloping of the posterior cranial base” was not recognised by all experts, leading to a lack of consensus. The three best rated CDC were chosen. With regard to the diagnosis congenital malformations, no consistent CDC were

formulated and rated. Some experts suggested that the criterion “dysmorphic features” would do. The results of the rating of all CDC in round 2 are presented in Appendix 1.

A second draft version of the screening instrument was made, containing the 10 most frequent occurring SA diagnoses with the two most relevant CDC for each diagnosis to examine during the differential diagnostic process. This selection had to be conferred with the experts of round 3.

The third research question focused on the opinion of the experts about the importance of the presented red flags to detect serious pathology. From a lists of 15 signs and symptoms, 6 had a score  $> 8.5$  ( $SD < 1.3$ ) on the 10-point interval scale. Based on these scores, a differentiation was made between “absolutely” ( $\geq 8.5$ ,  $SD < 1.3$ ) and “relatively” ( $< 8.5$ ) important red flags. Four symptoms: 1) acute onset; 2) stridor; 3) dyspnoea; and 4) increasing head tilt had a borderline score (Table 2).

TABLE 2 Rating of Red Flags in Delphi Round 2 and Expert panel Round 3

Red flags	Hints for disease or disorder	Round 2			Round 3	
		Mean (SD)	Median (range)	N 13	Consensus rate	Result: Agreement
<i>General history</i>						
<b>Heavy pain</b>	Fractures; Osteomyelitis; Retropharyngeal abscess	9.30 (1.06)	10 (7–10)	10	8/8	Yes
<b>Vomiting/drowsiness</b>	Increased intracranial pressure	9.20 (1.32)	10 (8–10)	11	8/8	Yes
<b>Trauma</b>	Intracranial injury	9.10 (1.29)	10 (7–10)	10	8/8	Yes
<b>Seizures/convulsions</b>	Epilepsy; Increased intracranial pressure; Sandifer syndrome	9.09 (1.04)	10 (7–10)	10	8/8	Yes
<b>Acute onset</b>	Infection; Abscess; Grisel syndrome	8.40 (1.90)	9 (3–10)	10	8/8	Yes
Stridor	Vascular ring	8.40 (1.90)	9 (5–10)	10	2/8	No
Dyspnoea	Vascular ring; Cardiac problem	8.40 (2.22)	9 (5–10)	10	2/8	No
Reflux	Sandifer syndrome; Pathological gastro-esophageal reflux	7.20 (2.49)	6 (4–10)	10	1/8	No
Fever	Infection; Abscess	6.90 (2.81)	6 (3–10)	10	1/8	No
<i>Specific examination</i>						
<b>Sunset phenomenon</b>	Increased intracranial pressure	9.60 (0.84)	10 (8–10)	10	8/8	Yes
<b>Bulging fontanel</b>	Increased intracranial pressure	8.91 (1.30)	10 (7–10)	11	8/8	Yes
Dysmorphic features	Syndrome (in general)	8.10 (2.13)	8 (4–10)	10	4/8	No
Lymphadenopathy	Infection; Pre-symptoms Juvenile Idiopathic Arthritis	7.30 (2.54)	7 (4–10)	10	0/8	No
<i>Abnormal course</i>						
<b>Increasing head tilt</b>	Infection; Tumor	8.50 (2.32)	9.5 (3–10)	10	8/8	Yes
Recurrent episodes	Benign paroxysmal torticollis	8.00 (2.06)	8 (6–10)	9	0/8	No

Legenda: N = number of experts; SD = standard deviation; Round 2: Likert-scale: 1 completely unimportant, 10=very important, always examine; Round 3: Red Flags in **bold** are established as **absolutely red flags**.

## Consistency

Only the scores of panelists who completed the major part of the survey (11/14) could be included in the consistency analysis, because of too many missing values. In round 1 of the Delphi process, Cronbach's- $\alpha$  was rather low: 0.67 (4 medical specialists, 7 physiotherapists; 34 CDC). After round 2, in which some experts choose the possibility of scoring only the highlighted items, the data of 8/13 panelists regarding a larger number of CDC (43 CDC) could be used to calculate Cronbach's- $\alpha$ , which was 0.89 (2 medical specialists, 6 physiotherapists).

## Round 3, expert meeting

Three newly formulated questions, based on the results of rounds 1 and 2, and research question 4 had to be answered in this final round.

- 1) Does the classification scheme cover all possible diagnoses of the health problem "asymmetry in infancy"?

After a clarification round, the pediatric physiotherapy experts discussed some bottlenecks. The discussions focussed on the nomenclature of cervical spine impairment and on a few causes that were never seen in infants less than 6 months of age, such as juvenile idiopathic arthritis. The nomenclature was changed and the mentioned diagnoses were removed from the scheme. The experts adopted the completeness of the classification scheme unanimously. They stated that the scheme was comprehensive for all known causes of symptomatic asymmetry in infants under 6 months of age. See Appendix 2 for the definite classification scheme.

- 2) Are life-threatening diagnoses sufficiently excluded by using the selected red flags?

To be able to answer this question, the panelists discussed the choice of 8.5 ( $SD < 1.30$ ) as a cutoff point. Four symptoms had a mean score very close to 8.5, with large SD values. The result of this choice was that potentially important red flags could be excluded. The panel decided to vote on two more red flags to possibly include in the list of absolutely red flags (acute onset and increasing head tilt). The panel decided that if the selected "absolutely red flags" are verified, relevant life-threatening diagnoses are sufficiently excluded. They advised, depending on the context, to consider the not selected red flags during the diagnostic process. The results of rounds 2 and 3 are both presented in Table 2.

- 3) Is there concordance in the panel regarding the selection of the most frequent occurring SA

diagnoses and most relevant CDC based on the results of the Delphi process?

The discussion focused on three points: 1) to add congenital muscular torticollis; 2) to add hearing disorders; and 3) to remove the Facial Palsy because this was seen as an asymmetry in the face itself, not leading to asymmetry in posture or movement patterns. The diagnoses malformations of the cervical, thoracic, and lumbar spine were merged (Table 1).

The panel then considered carefully the choices that were made concerning the reduction in CDC to two CDC that were rated  $\geq 4$  in round 2. The choices of CDC leading to 8/10 diagnoses were confirmed, with minor changes in terminology. Two extra CDC were selected to compensate a relatively high SD. With regard to craniosynostosis, the two best rated CDC, complemented with the extra CDC the plastic surgeon commented on, were accepted. In Table 3, the selected diagnoses with all final modifications regarding CDC are shown. Within the panel, clear consensus was established concerning selection of the most frequent occurring SA diagnoses and most relevant CDC. For the final version of the screening instrument see Appendix 2.

- 4) Is the established instrument useful and efficient for pediatric physiotherapists?

The fourth research question has been answered in writing by all experts of round 3 individually, after the panelists had received a written report of the meeting and the adaptations to the draft version of the instrument. All experts concluded the instrument to be clarifying, practical, and appropriate for clinical practice. They recommended adding a manual to the instrument, especially for the colleagues with minor experience, which has to be updated on a regular basis (Appendix 2).

## DISCUSSION

### Major findings

This qualitative study describes the development of an instrument for differential diagnostic screening in very young infants with asymmetry. The experts agreed on the terminology and classification into symptomatic and idiopathic asymmetries. The study went through a cycle of item generation and reduction on criteria to be used in the differential diagnostic process. The two Delphi rounds and the expert meeting provided consensus between the experts about a set of 21 CDC covering the 10 most frequent diagnoses of SA, which can easily and efficiently be completed in the first assessment of an

TABLE 3 Screening instrument symptomatic asymmetry: clinical diagnostic criteria

Symptomatic asymmetry	Clinical Diagnostic Criteria	Round 2 (n experts=13)					Round 1 (n experts=14)				
		Mean	SD	Med	Range	n	Mean	SD	Med	Range	n
Possible diagnosis (incidence/1000)	Findings										
1. Developmental dysplasia of the hip (40)	A. Unilateral pROM hip abduction <70° B. Leg length difference (Galeazzi)	4.55	0.52	5	4-5	11	4.55	1.04	5	2-5	11
2. Perinatal fracture of the clavicle (35)	A. Unilateral arm less active B. Pressure pain	4.45	0.52	4	4-5	11	4.18	1.33	5	1-5	11
3. Congenital muscular torticollis (20)	A. Persistent posture of the neck with heterolateral rotation, homolateral head-tilt and possibly hyperextension B. Pseudotumor in the m.SCM, 1-2 weeks post partum	4.18	0.98	4	2-5	11	3.75	1.29	4	2-5	12
4. Obstetric brachial plexus palsy (4)	A. Unilateral loss of function in the arm B. Asymmetric response on Moro-reflex	4.58	0.51	5	4-5	12	3.83	1.34	4	1-5	12
5. Ocular disorder	A. Poor fixation and following objects (not age-appropriate) B. Strabismus and/or nystagmus	4.33	0.50	4	4-5	9	4.00	0.95	4	3-5	12
6. Central nervous system disorder (2)	A. Abnormal movement patterns B1. Increased or decreased passive tone B2. Persistent ATNR**	4.80	0.42	5	4-5	10	4.64	0.67	5	3-5	11
7. Malformation of the spine	A. Asymmetry persisting in all postures B. Non-correctable scoliosis (actively nor passively)	4.36	0.50	4	4-5	11	4.25	1.29	5	1-5	12
8. Hearing disorder	A. Reaction on sound not age-appropriate B. No acoustical blink	4.67	0.49	5	4-5	12	4.20	0.92	4.5	3-5	10
9. Craniosynostosis / Lambdoid suture (.03)	A. Plagiocephaly post partum immediately visible and increasing B1. Trapezoid head shape B2. Downward sloping of the posterior cranial base**	4.33	0.82	4.5	3-5	6	3.33	1.58	3	1-5	9
10. Congenital abnormalities or malformations musculoskeletal (not spine) and / or chromosomal	A. Dysmorphic features (in general) #	4.73	0.47	5	4-5	11	4.58	0.67	5	3-5	12
		4.73	0.47	5	4-5	11	4.60	0.52	5	4-5	10
		4.45	0.52	4	4-5	11	4.33	0.78	4.5	3-5	12
		4.20	0.79	4	3-5	10	4.14	1.46	5	1-5	7
		4.29	1.25	5	2-5	7	*				
		3.90	1.10	4	2-5	7	3.77	1.36	4	1-5	13
		2.71	1.50	3	1-5	7	*				

Confirmation, by the Round 3 Expert panel, and results in Round 1 and 2, of the 10 most frequent occurring SA diagnoses with the two most relevant CDC to examine during the differential diagnostic process.

Abbreviations: med: Median; pRom: Passive range of motion; m.SCM: Sternocleidomastoid muscle; ATNR: Asymmetric Tonic Neck Reflex.

\*Added in Round 2; \*\*Selected in Round 3; # No consistent CDC formulated and rated.

infant with asymmetry. Furthermore, the experts reached concordance concerning a list of eight red flags to detect serious pathology. The consensus process was expressed in more than one way. The ranking between rounds 1 and 2 of the CDC was hardly different, but the convergence between the two rounds was obvious. The decrease of the SD, as an indication of increased consensus in the panel, was significant in almost all CDC. Moreover, consensus within the panel was seen as related to the homogeneity of the opinion of the individual panel members. The increase of Cronbach's- $\alpha$  over the two Delphi rounds was substantial, from 0.67 to 0.89. The value of 0.89 at the end of round 2 is close to the minimum value (i.e., 0.90) required for clinical application of a diagnostic instrument in individuals (Bland and Altman, 1997; Portney and Watkins, 2007).

## Results in context

The methodology of item generation and the process of expert validation have resulted in clinical agreement on the item selection (Murphy et al, 1998). The reduction in items created a practical, no time-consuming instrument. Only observations and manoeuvres were included in the CDC list. In clinical decision making, (family) history plays a role too as well as other factors like experience and skills in pattern recognition (Edwards et al, 2004; Higgs and Jones, 2000; Jensen, Gwyer, and Shepard, 2000). Evidence like sensitivity or specificity of the CDC was almost nonavailable. The instrument under study represents only the procedural part of the diagnostic process and does not pretend to be imperative. Therapists can add their own tests if they feel the need to. An extra complicating factor in the diagnostic process in young infants is the fact that they have an immature motor system. Infants may show transient features and a rapidly changing motor performance (Rosenbaum, 2006).

## Strengths and weaknesses

The method and source triangulation strengthened the design of this study. Both methods have advantages and disadvantages, which could compensate each other. For example, the medical specialists had different subspecialty backgrounds. A disadvantage of consensus methods could be the smaller impact of a minority. In relevant cases, like the choice of CDC in recognising craniosynostosis, strong arguments of the expert in the field were discussed and rewarded in round 3, despite a smaller rating. One more example is the method of rating anonymously in the Delphi

rounds vs. voting in the context of group dynamics at the expert meeting. Another characteristic of this study was the iterative process. The four research questions gradually became more explicit over the rounds and fitted well with the phase of development. The choices made during this process directed the outcome of the study. It is unclear whether the outcome would have changed if other decisions were made.

This study has some weaknesses that may have induced bias. First, a consensus method can be biased when the process starts from a narrow point of view (Graham, Regehr, and Wright, 2003). The items included in the Delphi study were formally collected from literature review (Nuysink, van Haastert, Takken, and Helders, 2008) and key informant interviews, to have a wide scope on all diagnoses and CDC involved. We are aware of the fact that the content of the starting list influences the item generation process. To compensate for this a priori structured list, the experts in the Delphi rounds had the possibility to comment on the items and to add new items. The items judged in the expert meeting were explicitly based on the results of the two Delphi rounds. Second, comparable question marks have to be raised at the point of expert selection. The heterogeneity in panel composition, the experience, and specialty of the experts do have an effect on group judgement (Fitch et al, 2001; Hasson, Keeney, and McKenna, 2000; Murphy et al, 1998). The experience of the medical specialists in the Delphi panels was not inquired; the pediatric physiotherapy panel had an extensive experience. The choice for two subgroups in the two Delphi rounds, medical specialists and pediatric physiotherapists, made the panel heterogeneous and created the possibility to compare views on a relevant topic for both professions. Despite an a priori promise, not all the initial participants performed the survey. The three panelists who did not participate were from relevant medical specialties in the diagnostic process. The impact of their nonparticipation is unclear. In the pediatric physiotherapy panel in the third round, a minority of the panel members participated in the Delphi rounds too. On the other hand, the five new experts in round 3 could show a more objective vision towards the scores in the previous rounds. The choice to invite only physiotherapists in the final expert meeting made it possible to focus on their own diagnostic process. Finally, the fact that a number of CDC have not been rated can have caused hidden bias and as such influenced the outcome. We did not expect the medical specialists to skip the items beyond their specialty. A reasonable explanation can be that medical specialists are used to judge only issues regarding their own specialty and consult other specialists for other health questions. Therefore, the combination of

general practitioners and specialists was valuable for the purpose of our instrument.

## Implications

We advise pediatric physiotherapists to use the red flag list in the first intake to exclude serious pathology. The differential diagnostic instrument can be used to formulate and verify hypotheses during the diagnostic process (Rothstein, Echternach, and Riddle, 2003). In doubt, the infants must be referred to a pediatrician to confirm the diagnosis. The diagnosis idiopathic asymmetry can only be made “per exclusionem” (Appendix 2).

## CONCLUSION

A screening instrument was developed to distinguish symptomatic asymmetry in the first 6 months of life. The instrument contains a classification scheme, a set of clinical diagnostic criteria for differential diagnostics, and a list of red flags and is based on literature search and expert consensus.

Application of the instrument in new studies can be a starting point toward collecting evidence (Graham, Regehr, and Wright, 2003). More research is needed to confirm the usefulness of the instrument. The next stage is to investigate validity by observations, cross-validation in a sample of infants, who are already diagnosed on a particular symptomatic asymmetry and in determining the predictive validity of the criteria.

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## REFERENCES

- Arce D, Sass P, bul-Khoudoud H 2001 Recognizing spinal cord emergencies. *American Family Physician* 64: 631–638
- Arcury TA, Quandt SA 1998 Qualitative methods in arthritis research: Sampling and data analysis. *Arthritis Care and Research* 11: 66–74
- Ballock RT, Song KM 1996 The prevalence of nonmuscular causes of torticollis in children. *Journal of Pediatric Orthopedics* 16: 500–504
- Bland JM, Altman DG 1997 Cronbach's alpha. *British Medical Journal* 314: 572
- Boere-Boonekamp MM, Bunge-van Lent F, Roovers EA, Haasnoot-Smallegange M 2005 Positional preference in infants: Prevalence, prevention and care. *Tijdschrift Voor De Jeugdgezondheidszorg* 5: 92–97
- Boere-Boonekamp MM, van der Linden-Kuiper AT 2001 Positional preference: Prevalence in infants and follow-up after two years. *Pediatrics* 107: 339–343
- Bredenkamp JK, Hoover LA, Berke GS, Shaw A 1990 Congenital muscular torticollis. A spectrum of disease. *Archives of Otolaryngology-Head and Neck Surgery* 116: 212–216
- Carpenter J, Hammell K 2000 Evaluating qualitative research. In: Hammell M, Carpenter C, Dyck I (eds), *Using Qualitative Research*, pp 110–111. Edinburgh, Churchill Livingstone
- de Chalain TM, Park S 2005 Torticollis associated with positional plagiocephaly: A growing epidemic. *Journal of Craniofacial Surgery* 16: 411–418
- de Jonge GA, Hoogenboezem J 2005 Epidemiology of 25 years of crib death (sudden infant death syndrome) in the Netherlands; Incidence of crib death and prevalence of risk factors in 1980–2004. *Ned Tijdschr Geneesk* 149: 1273–1278
- Do TT 2006 Congenital muscular torticollis: Current concepts and review of treatment. *Current Opinion in Pediatrics* 18: 26–29
- Edwards I, Jones M, Carr J, Braunack-Mayer A, Jensen GM 2004 Clinical reasoning strategies in physical therapy. *Physical Therapy* 84: 312–330
- Engelbert R, van Vlimmeren L 2006 Pediatric physiotherapy in relation to pediatric orthopaedics. In: van Empelen R, Nijhuis-van der Sanden R, Hartman A (eds), *Pediatric Physiotherapy*, 2nd edn, pp 305–315. Maarssen, The Netherlands, Elsevier
- Essen Pv, Sleijpen F, Crombag H 2004 Pediatric physiotherapy in infants 0–2 years, a sketch, 1st edn, pp 31–35. Heerlen, The Netherlands, Foundation SBOK
- Fitch K, Bernstein SJ, Aguilar MS, Burnand B, Lacalle JR, Van het Loo M, McDonnell J, Vader JP, Kahan JP 2001 The RAND/UCLA Appropriateness method user's manual, pp 5–6, 23. Santa Monica, RAND Corporation
- Graham B, Regehr G, Wright JG 2003 Delphi as a method to establish consensus for diagnostic criteria. *Journal of Clinical Epidemiology* 56: 1150–1156
- Greene G 2001 “Red Flags”: Essential factors in recognizing serious spinal pathology. *Manual Therapy* 6: 253–255
- Hasson F, Keeney S, McKenna H 2000 Research guidelines for the Delphi survey technique. *Journal of Advanced Nursing* 32: 1008–1015
- Higgs J, Jones M 2000 *Clinical Reasoning in the Health Professions*, 2nd edn, p 97. London, Butterworth-Heinemann
- Hutchison BL, Hutchison LA, Thompson JM, Mitchell EA 2004 Plagiocephaly and brachycephaly in the first two years of life: A prospective cohort study. *Pediatrics* 114: 970–980
- Hutchison BL, Thompson JM, Mitchell EA 2003 Determinants of nonsynostotic plagiocephaly: A case-control study. *Pediatrics* 112: e316
- Jensen GM, Gwyer J, Shepard KF 2000 Expert practice in physical therapy. *Physical Therapy* 80: 28–43

- Jones J, Hunter D 1995 Consensus methods for medical and health services research. *British Medical Journal* 311: 376–380
- Kane AA, Mitchell LE, Craven KP, Marsh JL 1996 Observations on a recent increase in plagiocephaly without synostosis. *Pediatrics* 97: 877–885
- L'Hoir MP, Engelberts AC, van Well GT, McClelland S, Westers P, Dandachli T, Mellenbergh GJ, Wolters WH, Huber J 1998 Risk and preventive factors for cot death in The Netherlands, a low-incidence country. *European Journal of Pediatrics* 157: 681–688
- Murphy MK, Black NA, Lamping DL, McKee CM, Sanderson CF, Askham J, Marteau T 1998 Consensus development methods, and their use in clinical guideline development. *Health Technology Assessment* 2: 3–6
- Nuysink J, van Haastert IC, Takken T, Helders PJ 2008 Symptomatic asymmetry in the first six months of life: differential diagnosis. *European Journal of Pediatrics* 167: 613–619
- Peitsch WK, Keefer CH, LaBrie RA, Mulliken JB 2002 Incidence of cranial asymmetry in healthy newborns. *Pediatrics* 110: e72
- Persing J, James H, Swanson J, Kattwinkel J 2003 Prevention and management of positional skull deformities in infants. *Pediatrics* 112: 199–202
- Pollack IF, Losken HW, Fasick P 1997 Diagnosis and management of posterior plagiocephaly. *Pediatrics* 99: 180–185
- Portney LG, Watkins MP 2007 *Foundations of clinical research: Applications to practice*, 3rd edn, pp 341–343, 606. New Jersey, Prentice-Hall
- Rosenbaum P 2006 Classification of abnormal neurological outcome. *Early Human Development* 82: 167–171
- Rothstein JM, Echternach JL, Riddle DL 2003 The Hypothesis-Oriented Algorithm for Clinicians II (HOAC II): A guide for patient management. *Physical Therapy* 83: 455–470
- Stellwagen L, Hubbard E, Chambers C, Jones KL 2008 Torticollis, facial asymmetry and plagiocephaly in normal newborns. *British Medical Journal* 93: 827–831
- van Kranen-Mastenbroek VH, Folmer KB, Caberg HB, Kingma H, Blanco CE, Troost J, Hasaart TH, Vles JS 1997 The influence of head position and head position change on spontaneous body posture and motility in full-term AGA and SGA newborn infants. *Brain Development* 19: 104–110
- Van Vlimmeren LA, Helders PJ, Van Adrichem LN, Engelbert RH 2004 Diagnostic strategies for the evaluation of asymmetry in infancy—a review. *European Journal of Pediatrics* 163: 185–191
- Van Vlimmeren LA, van der Graaf Y, Boere-Boonekamp MM, L'Hoir MP, Helders PJ, Engelbert RH 2007 Risk factors for deformational plagiocephaly at birth and at 7 weeks of age: A prospective cohort study. *Pediatrics* 119: e408–e418
- World Health Organisation 2007 *International Classification of Diseases (ICD). Part 1*. Geneva, World Health Organisation

**APPENDIX 1 Manuscript Symptomatic asymmetry in very young infants**

## Summary Round 2 Result of Rating Clinical Diagnostic Criteria

Symptomatic asymmetry	Mean	Median	SD
Developmental dysplasia of the hip			
<b>Unilateral pRoM hip abduction &lt; 70 (in flexion-abd-exorot)</b>	<b>4.55</b>	<b>5.0</b>	<b>0.52</b>
<b>Leg length difference (Galeazzi)</b>	<b>4.18</b>	<b>4.0</b>	<b>0.75</b>
Posture of one leg > adduction/endorotation/extension	3.89	4.0	0.78
Asymmetrical skin folds in inguinal and upper thigh region	3.00	3.0	1.32
Unilateral leg less active	2.56	3.0	0.73
Perinatale fracture of the clavicle			
<b>Unilateral arm less active</b>	<b>4.45</b>	<b>4.0</b>	<b>0.52</b>
<b>Pressure pain (first weeks only)</b>	<b>4.18</b>	<b>4.0</b>	<b>0.98</b>
Homolateral lateroflexion of the head	3.75	3.5	0.89
Palpable thickness in clavicle	3.63	4.0	1.41
Obstetric brachial plexus palsy			
<b>Unilateral loss of function of the arm</b>	<b>4.80</b>	<b>5.0</b>	<b>0.42</b>
Unilateral arm less active	4.43	5.0	0.79
Position unilateral arm more elbow extension and shoulder endorotation (C5-7)	4.38	4.5	0.74
<b>Asymmetric response on Moro-reflex</b>	<b>4.36</b>	<b>4.0</b>	<b>0.50</b>
Asymmetric recoil reaction in arms	3.63	4.0	0.92
Asymmetric palmar grasp reaction	3.29	4.0	1.60
Asymmetric traction response in arms	3.14	3.0	1.35
Asymmetric response in arms in pull-to-sit manoeuvre	3.14	3.0	1.35
Preference heterolateral rotation of the head	3.13	3.0	0.99
Cervical rotation not restricted	3.00	3.0	0.93
Ocular Disorders			
<b>Poor fixation and following objects (not age-appropriate)</b>	<b>4.67</b>	<b>5.0</b>	<b>0.49</b>
Difficult to make eye contact	4.58	5.0	0.51
<b>Nystagmus</b>	<b>4.33</b>	<b>4.0</b>	<b>0.65</b>
Straying eyes	3.88	4.0	0.64
No optical blink	3.44	4.0	1.13
<b>Strabismus (beyond 3 months)</b>	<b>3.22</b>	<b>3.0</b>	<b>0.83</b>
Startle-like reaction on unexpected matters	2.67	3.0	1.00
Doll's head phenomenon	2.67	3.0	1.22
Horizontal Vestibular Linear Reaction (optokinetic provocation) abnormal	2.44	2.0	1.13
Central nervous system disorder			
<b>Abnormal movement patterns</b>	<b>4.70</b>	<b>5.0</b>	<b>0.48</b>
<b>Increased or decreased passive tone</b>	<b>4.50</b>	<b>5.0</b>	<b>0.97</b>
(Unilateral) loss of variation and dissociation in movement patterns (e.g. General	4.43	5.0	0.79
<b>Persistent Asymmetric Tonic Neck Reflex (ATNR)</b>	<b>4.33</b>	<b>4.5</b>	<b>0.82</b>
Asymmetric posture increasing during movement	3.57	4.0	0.98
Abnormal response on postural reactions	3.43	3.0	1.62
Asymmetry in palmar grasp reflex/reaction	3.00	3.0	1.15
Asymmetry in plantar grasp reflex	2.86	3.0	1.35

*(Continued)*

## Summary Round 2 Result of Rating Clinical Diagnostic Criteria (continued)

Symptomatic asymmetry	Mean	Median	SD
Malformation of the cervical spine			
<b>Asymmetry persisting in all postures</b>	<b>4.73</b>	<b>5.0</b>	<b>0.49</b>
Cervical scoliosis	4.27	4.0	0.79
Abnormal (asymmetric) appearance of the neck (webbing, l'homme sans cou)	4.13	4.0	0.41
Post partum immediately visible	3.88	4.0	0.82
Malformation of the thoraco/lumbar spine			
<b>Non-correctable scoliosis (passively)</b>	<b>4.73</b>	<b>5.0</b>	<b>0.47</b>
Scoliotic posture	4.00	4.0	0.93
Asymmetric response on Galant reaction	3.80	4.0	0.79
Gibbus (in horizontal suspension)	3.00	3.0	1.07
Persistent skin folds concave side, visible in all positions	2.63	3.0	0.92
Congenital muscular torticollis			
<b>Asymmetric posture of the neck with heterolateral rotation, homolateral head-tilt and persistency or increase of that posture in all positions</b>	<b>4.58</b>	<b>5.0</b>	<b>0.51</b>
<b>Pseudotumor in the m SCM palpable</b>	<b>4.33</b>	<b>4.0</b>	<b>0.50</b>
<b>The condition appears 1-2 weeks post partum</b>	<b>4.33</b>	<b>4.0</b>	<b>0.71</b>
Restricted aRoM and pRoM of the neck in opposite direction	4.11	4.0	0.78
Pseudotumor m.SCM visible	3.78	4.0	0.97
pROM in opposite direction >10 degrees restricted	3.78	3.0	0.97
Asymmetric reaction in head at pull-to sit manoeuvre	2.89	3.0	1.36
Skin rash homolateral in neck folds	1.88	2.0	0.83
Craniosynostosis			
<b>Abnormal head shape post partum immediately visible and increasing</b>	<b>4.29</b>	<b>5.0</b>	<b>1.25</b>
<b>Trapezoid head shape (lambdoid suture)</b>	<b>3.90</b>	<b>4.0</b>	<b>1.10</b>
Deviant growth curve for circumference of the skull	3.78	4.0	0.97
Palpable thickening of a cranial suture	2.89	3.0	1.17
<b>Homolateral inferior tilt of the posterior skull base</b>	<b>2.71</b>	<b>3.0</b>	<b>1.50</b>
Hearing disorder			
<b>Reaction on sound not age-appropriate</b>	<b>4.45</b>	<b>5.0</b>	<b>0.52</b>
<b>No acoustical blink</b>	<b>4.20</b>	<b>4.0</b>	<b>0.79</b>
No vocalisation in interaction (beyond 2 months)	3.88	4.0	0.64
Startle-like reaction on unexpected matters	2.63	3.0	0.92
Abnormal shaped auricle	1.75	1.5	0.89

Criteria in bold face have been selected in the concept version of the screening instrument after Round 2.



## Appendix 2B Symptomatic asymmetry classification scheme

Possible differential diagnoses in young infants

International classification of diseases	Localisation	Diagnosis specification
<i>Prenatal origin</i>		
Diseases of the eye and adnexa		<ul style="list-style-type: none"> <li>- Congenital nystagmus</li> <li>- Restrictive or paralytic strabismus</li> <li>- Congenital homonymous hemianopia</li> <li>- Monocular blindness</li> </ul>
Diseases of the ear and mastoid process		<ul style="list-style-type: none"> <li>- Unilateral deafness or partial hearing loss</li> </ul>
Congenital malformations, deformations <i>musculoskeletal</i>	M.Sternocleidomastoid	<ul style="list-style-type: none"> <li>- Congenital muscular torticollis</li> </ul>
	Spine	<ul style="list-style-type: none"> <li>- Klippel Feil syndrome</li> <li>- Sprengels deformation</li> <li>- Hemivertebrae</li> <li>- Hemiatlas</li> <li>- Congenital scoliosis</li> </ul>
	Other	<ul style="list-style-type: none"> <li>- Craniosynostosis (frequently part of syndrome)</li> <li>- Aplasia/hypoplasia facies/neck/trunk muscles</li> </ul>
Congenital malformations, deformations and chromosomal abnormalities <i>over all</i>	Localised	<ul style="list-style-type: none"> <li>- Laryngomalacia</li> <li>- Tracheomalacia</li> <li>- Vascular ring</li> </ul>
	Generalised	<ul style="list-style-type: none"> <li>- Syndromes, e.g., Goldenhar, hemihypertrophia</li> </ul>
<i>Perinatal origin</i>		
Disease of the nervous system	Central	<ul style="list-style-type: none"> <li>- Tone regulation disorder (hemiplegia)</li> </ul>
	Peripheral	<ul style="list-style-type: none"> <li>- Obstetric Brachial Plexus Palsy</li> <li>- N. Facial Palsy</li> </ul>
Childbirth		<ul style="list-style-type: none"> <li>- Fracture of the clavicle, humerus</li> </ul>
<i>Postnatal origin/acquired</i>		
Infectious diseases	Oto-rhino-laryngology	<ul style="list-style-type: none"> <li>- Grisel syndrome after pharyngitis e.g. (&gt;6 months)</li> <li>- Retropharyngeal abscess</li> <li>- Lymfadenopathy neck region</li> </ul>
	Other	<ul style="list-style-type: none"> <li>- Osteomyelitis cervicobrachial region</li> <li>- Soft tissue infections</li> <li>- Presymptoms Juvenile Idiopathic Arthritis (&gt;6 months)</li> </ul>
Neoplasms	Head/neck region:	<ul style="list-style-type: none"> <li>- Posterior fossa tumor</li> <li>- Intramedullar tumor (astrocytoma)</li> <li>- Cerebellar tumor</li> </ul>
Diseases of the respiratory system		<ul style="list-style-type: none"> <li>- Compulsive posture due to dyspnoea</li> <li>- Tracheostoma</li> </ul>
Diseases of the nervous system		<ul style="list-style-type: none"> <li>- Epilepsy</li> <li>- Syringomyely</li> <li>- Increased intracranial pressure</li> </ul>
Diseases of the digestive system		<ul style="list-style-type: none"> <li>- Pathologic gastroesophageal reflux</li> <li>- Peroxysmal torticollis</li> <li>- Sandifer syndrome</li> </ul>
Diseases of the musculoskeletal system		<ul style="list-style-type: none"> <li>- Developmental dysplasia of the hip</li> </ul>
Injury		<ul style="list-style-type: none"> <li>- Trauma</li> <li>- Abuse</li> </ul>
External causes (complications)		<ul style="list-style-type: none"> <li>- Status postsurgical intervention</li> <li>- Status postelongated drip-feeding</li> <li>- Ventriculo-Peritoneal drain</li> </ul>

## Appendix 2C Explanation Differential diagnostic screening instrument on symptomatic asymmetry in young infants

**Objective:** A differential diagnostic screening instrument for pediatric physiotherapists (PPTs) to distinguish a symptomatic asymmetry (SA) in the clinical evaluation of young infants (< six months of age) with an asymmetric head posture, examining red flags and clinical diagnostic criteria (CDC) at the first examination of the infant. The red flags and CDC can be used to formulate and verify hypotheses about the origin of the asymmetry. If no red flags or CDC are found, the diagnosis idiopathic asymmetry (IA) can be stated 'per exclusionem'. Subsequently, additional examination procedures are needed for the continuing PPT clinical reasoning process of both SA and IA and to determine an indication of the need for intervention.

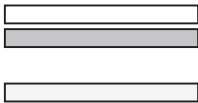
**Content:** The instrument comprises a chart and a short instruction to examine CDC.

The front of the chart consist of a scheme of the differential diagnostic (DD) process, red flags to exclude serious pathology, and clinical diagnostic criteria (CDC) to detect the most frequent SA diagnoses. On the back, a comprehensive classification scheme can be found with all possible diagnoses that may lead to an SA.

In this short manual the use of the chart will be explained.

### Chart front

The figure at the top left of the sheet illustrates the DD process. If, with the help of this instrument, red flags or CDC are found by the PPT, medical consultation or referral will be needed to confirm the diagnosis in most cases.



**Red flags:** At the top right of the sheet, the red flags are listed, subdivided in (1) symptoms asked for in the general history interview, (2) signs that were seen during examination, and (3) signs of an abnormal course of the asymmetric posture. The eight (in bold printed) red flags are very important and are always an indication for referral. The remaining seven red flags can be considered as relatively important. The PPT has to make a consideration, depending on the context, whether or not consultation is needed.

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Red flags

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**General history**

**Severe pain**

**Vomiting / drowsiness**

**Trauma**

**Seizures / convulsions**

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**Clinical diagnostic criteria to detect SA** The table with 21 CDC to detect the 10 SA diagnoses with the highest incidence is at the bottom of the sheet. To facilitate the DD process, the table starts with the diagnosis with the highest incidence (between brackets the known incidence of the disease per 1000 infants). The most relevant CDC are in the third column, the CDC in the fourth column are additional.

	Symptomatic asymmetry	Clinical diagnostic criteria	
	Possible diagnosis (inc/1000)	Most relevant findings	Additional findings
1.	Developmental dysplasia of the hip	Unilateral prom hip abduction <70	Leg length difference (Galeazzi)

The CDC can easily and efficiently be detected in the first examination of an infant with an asymmetric head posture, order at random, but preferably starting with the hands off examination, followed by the hands on manoeuvres. The set of CDC is not imperative, the PPT can add his own tests if he feels the need to.

## Chart back

On the back of the chart, a comprehensive overview is given of current known disorders and diseases possibly leading to a symptomatic asymmetry, classified according to the International Classification of Diseases (ICD10) and stratified by time of origin (pre-, peri-, or postnatal).

## Instructions to examine CDC

Only specific manoeuvres are described

## Developmental dysplasia of the hip

CDC1: pRoM can best be examined symmetrically in supine position, moving the hips to flexion-exorotation-abduction position.

CDC2: Leg length is best examined with the Galeazzi-test, by looking at the symmetry of the height of the knees when the infant is supine. A positive Galeazzi sign (unequal knee heights) suggests a unilaterally dislocated hip.

## Congenital muscular torticollis

CDC2: Palpation of the sternocleidomastoid muscle over the full length. A pseudotumor is usually not palpable in the first two weeks after birth.

## Central nervous system disorder

CDC1: Special attention to left/right differences in movement patterns of the arms.

CDC2B: An ATNR that persists beyond the first months is abnormal. A strongly pronounced ATNR is suspect at all ages.

## Craniosynostosis

CDC 2A: From a cranial view, the trapezoid-shaped head can be seen in infants with a premature closure of one of the lambdoid cranial sutures. The DD from (non-synostotic) deformational plagiocephaly (DP), with a more parallelogram-shaped head is important. The position of the ear is different too. If one of the other sutures is involved another shape has to be expected, quite different from the DP.

CDC2B: From a posterior view an inferior tilt of cranial base can be seen, resulting in inferior displacement of the homolateral ear.

## Symptomatic asymmetry

In case the PPT examination of the CDC or the presence of a red flag indicates that an SA diagnosis must be considered, the infant has to be referred for medical diagnostics. In some cases consultation of a physician will suffice, for example in diagnosis 2 and 3: A *Fracture of the clavicle* can have been the origin of the head preference, but only in the first weeks. *Congenital muscular torticollis* can first be treated by a PPT, but the strategies may differ from the intervention to normalise an idiopathic asymmetry like postural torticollis. Only if treatment is not effective enough, referral to a medical specialist is needed to consider surgical intervention.

In case of an *Obstetrical brachial plexus palsy* or a *Central nervous system disorder*, the infants usually need to be treated by a PPT, but firstly the diagnosis has to be stated by a medical specialist.

## Idiopathic asymmetry

If no indication for symptomatic asymmetry has been found, the asymmetry can be classified as idiopathic. IA is the most prevalent condition in young infants. Several localisations of idiopathic asymmetry can be distinguished, like deformational plagiocephaly, postural torticollis, and postural scoliosis. This DD instrument does not cover that aspect.

The DD instrument for symptomatic asymmetry in young infants has been developed by Dutch medical specialists and pediatric physiotherapists, based on review of the literature and a Delphi-study on expert (content) validity. In future research, (predictive) validity and reliability will be investigated.