Constipation in infancy and childhood : New insights into pathophysiological aspects and treatment

Bekkali, N.L.H.

CHAPTER 2

Infant Stool Form Scale: development and results

Noor Bekkali
Sofie Hamers
Johannes Reitsma
Letty van Toledo
Marc Benninga

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ABSTRACT

Background

For infants an instrument describing stool characteristics has yet to be developed.

Aim

To develop an infant stool scale describing consistency, amount and colour and test its usefulness by assessing the differences between term and preterm infants, between breastfed and formula fed infants and examining interobserver and intraobserver variability.

Methods

Information about gestational age, postnatal age, and feeding type was collected in relation to each photograph taken. An infant stool form scale describing consistency (4-point scale), amount (4-point scale) and colour (6 categories) was developed. All photographs were scored twice with the newly developed scale to assess interobserver and intraobserver variability. Consensus database describing stool characteristics was developed.

Results

A total of 555 photographs of infant stools were analysed. Sixty (11%) of the infants were term and 495 (89%) were born prematurely. No differences were found in stool characteristics between preterm and term infants. Breastfed infants had smaller amounts of stools compared with formula-fed infants ($p<0.001$).

The interobserver weighed K value (95% CI) was good for consistency and amount; simple K value was good for colour. For observers I and II, intraobserver K values were excellent.

Conclusion

This “Amsterdam” stool form scale is useful to assess defecation patterns in both premature and term born infants.

INTRODUCTION

To date, a stool form scale describing stool characteristics such as consistency, amount and colour of faeces in infants has yet to be developed. In adults, the Bristol Stool Form Scale (BSFS) appears to be a reliable tool for describing and classifying stool appearance. [1] It consists of a 7-point scale in which stool consistency together with form of stool are described for every point in this scale. For example, score 1 describes stools that are hard lumps, like nuts (hard to pass) while score 4 describes stools like a sausage or snake, smooth and soft. The BSFS is used in clinical practice to monitor change in intestinal function. Higher stool water content was associated with more rapid gastrointestinal transit and higher scores on the BSFS. (1) The converse was true for stool with less water content. [1] More importantly the BSFS has proved acceptable both to subjects in epidemiological surveys and to patients attending gastrointestinal clinics for measuring their stool form. [2] Furthermore, it has been suggested to use this scale in research to prospectively assess stool form to discriminate between patients with functional defecation disorders such as irritable bowel syndrome, diarrhoea and constipation. [3-6]

A comparable scale for infants is lacking, but it would help both parents and clinicians in describing and differentiating between physiological and pathological stool appearance. Therefore the aim of this study was to develop an infant stool form scale and test its usefulness by assessing the difference in stool characteristics between term and preterm born infants and between breastfed (BF) and formula-fed (FF) infants and examining interobserver and intraobserver variability.

METHODS

Scale development

Daily digital photographs were taken from all stools of preterm and term infants during their hospital stay in an academic and nonacademic hospital in Amsterdam the Netherlands, between August and October 2006. Stools of otherwise healthy infants without metabolic, congenital diseases or gastrointestinal disorders requiring surgery were photographed. Photographs were taken at daytime by 2 researchers with a digital camera (zoom lens, original magnification x4 and 7.2 megapixels) while positioning the diaper a distance of 20 cm from the digital camera. The macro function of the digital camera was applied for each photograph. To be able to take pictures of fresh stool, nurses informed researchers every 4 hours about the production of faeces in diapers of all admitted infants during daytime. This pool of stool photographs was evaluated by 2 observers, a medical student (I) and a medical doctor (II). The choice of characteristics to include in the stool

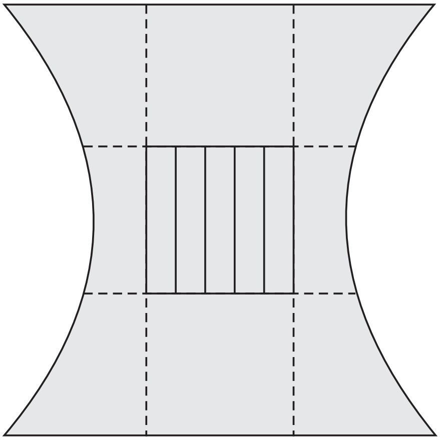

Figure 1. Hatched quadrangle: reference surface for defining the scales for the amount of stools.

scale was determined by face validity (by examining the items, the scale should measure what it should measure). [7] In a face-to-face meeting the observers reached consensus on 4 typical photographs for describing the consistency as watery, soft, formed and hard. For describing the amount of stool each diaper was divided into 9 areas; the middle area (99cm^2) was the reference surface area (Figure 1). Then 4 typical photographs were chosen upon consensus by the 2 observers to describe the amount into: 'smear', <25%, 25-50% and >50% of faeces in the reference area. To classify colour, 6 photographs were chosen illustrating the colours yellow, orange, green, brown, meconium and clay-coloured. These typical photographs (n=14 pictures) describing the different categories of consistency, amount and colour were used as visual anchor points in the newly developed infant stool form scale (Figure 2).

Interobserver and intraobserver variation

With this newly developed stool scale, all photographs were then scored in random order to assess interobserver variability for the items consistency, amount and colour. The 2 observers scored the pictures independently from each other. Photographs scored by the observers contained information about the age of the infant (gestational age [GA] and age in days after birth) and type of feeding. This information was used to further analyse stool characteristics in relation to age and type of feeding. After 3 months, the same photographs were scored a second time by the same 2 observers to assess intraobserver variability.

Differences in stool characteristics by gestational age and type of feeding

For these analyses, a consensus reading for all stool aspects was constructed based on consensus classification by the 2 observers and described in Table 1.

Table 1. The scored items consistency, amount and color in relation to GA

Stool characteristics	GA<=28	29=>GA<34	34=>GA<37	GA>=37	Total
Consistency					
Watery	4	2	6	2	14
Soft	98	134	67	37	336
Formed	55	71	33	20	179
Hard	9	10	6	1	26
Amount					
Smear	3	4	0	0	7
Up to 25%	72	87	55	25	239
25-50%	73	99	38	27	237
>50% of reference area	18	27	19	8	72
Colour					
Yellow	81	96	45	21	243
Brown	41	74	40	18	173
Green	10	9	3	11	33
Orange	6	8	9	5	28
Meconium	26	28	13	4	71
Clay coloured	2	2	2	1	7

Premature infants were divided into 3 groups according to their GA in weeks; group 1: GA ≤ 28 weeks; group 2: 29^{3}GA≤32 and group 3: 33^{3}GA≤36. For evaluation of differences in stool characteristics between young and older infants three age groups were selected based on the percentiles of the total age (in days after birth) of all participating infants. Group I were infants of 15 days and younger (25th percentile), group II consisted of infants older than 15 days and younger than 30 days (25-75th percentile) and age groups III (≥75th percentile) were infants 30 days and older.
The study was approved by the Medical Ethical Committee of the Academic Medical Centre of Amsterdam.

STATISTICAL ANALYSES

The number of photographs of stools and infant characteristics like gestational age, age in days after birth and type of feeding were analysed in a descriptive way. The interobserver and intraobserver variability were evaluated by calculating the proportion of exact agreement and the kappa statistics for nominal data (colour) and weighted kappa's (Fleiss & Cohen) for items in which there is a natural ordering of categories (consistency and amount). [8-10] Agreement, based on the value of kappa (k), was categorized, as described by Altman, as poor (k≤0.2), fair (0.21≤k≤0.40), moderate (0.41≤k≤0.60), good (0.61≤ k≤0.80) or excellent (0.81≤ k≤1.00). [9]

The Mann-Whitney test was used to examine differences in stool consistency, amount and colour between premature and term born infants and between breastfed (BF) and formula fed (FF) infants. Ordinal regression analyses were performed to evaluate the difference in stool consistency; amount and colour (when ranged ordinal from dark to light colours) with time divided over 3 age groups. All analyses were performed using SPSS statistical software (SPSS Inc.14.0.2). All p-values less than 0.05 were considered statistically significant.

RESULTS

Baseline characteristics

A total of 907 digital photographs of infant stools were taken of which 555 could be analysed. The other photographs (n=442) were duplicates or of poor quality and were therefore not useful for further analysis. Images of 555 stools of infants with a median GA of 31 weeks (range: 25-42) and with a median age of 15 days after birth (range: 1-120) were analysed (figure 3 and 4). Sixty of the participating infants (11%) were term born. Of the premature born infants 166 (30%) were born ≤ 28 weeks of gestation; 217 (39%) between 29 and 32 weeks and 112 (20%) between 33 and 36 weeks. One hundred and six infants (19%) received BF and 237 (43%) were FF. Two hundred and five infants (37%) were simultaneously breastfed and formula fed. Seven infants (1%) did not receive enteral feeding.

Infant Stool Form Scale

The final infant stool form scale describing consistency (ordered categories), amount (ordered categories) and colour together with typical photographs illustrating each category is given in figure 2.

Interobserver and intraobserver variation

The proportion of photographs in which the exact same category was assigned by the 2 observers was 78% for consistency, 71% for amount and 68% for colour. The proportion of photographs in which the category assignment differed in more than 2 categories between the observers was 0% for consistency and amount; and 0.35% for colour.

The interobserver weighed k value (95% CI) was 0.68 (0.62 to 0.74) for consistency, 0.74 (0.69 to 0.78) for amount and simple k value of 0.75 (0.70 to 0.79) for colour. After 3 months, the observers scored the same photographs again showing an excellent intraobserver agreement. The intraobserver weighed k value was 0.84 (0.75 to 0.93) and 0.89 (0.83 to 0.94) for respectively consistency and amount; and

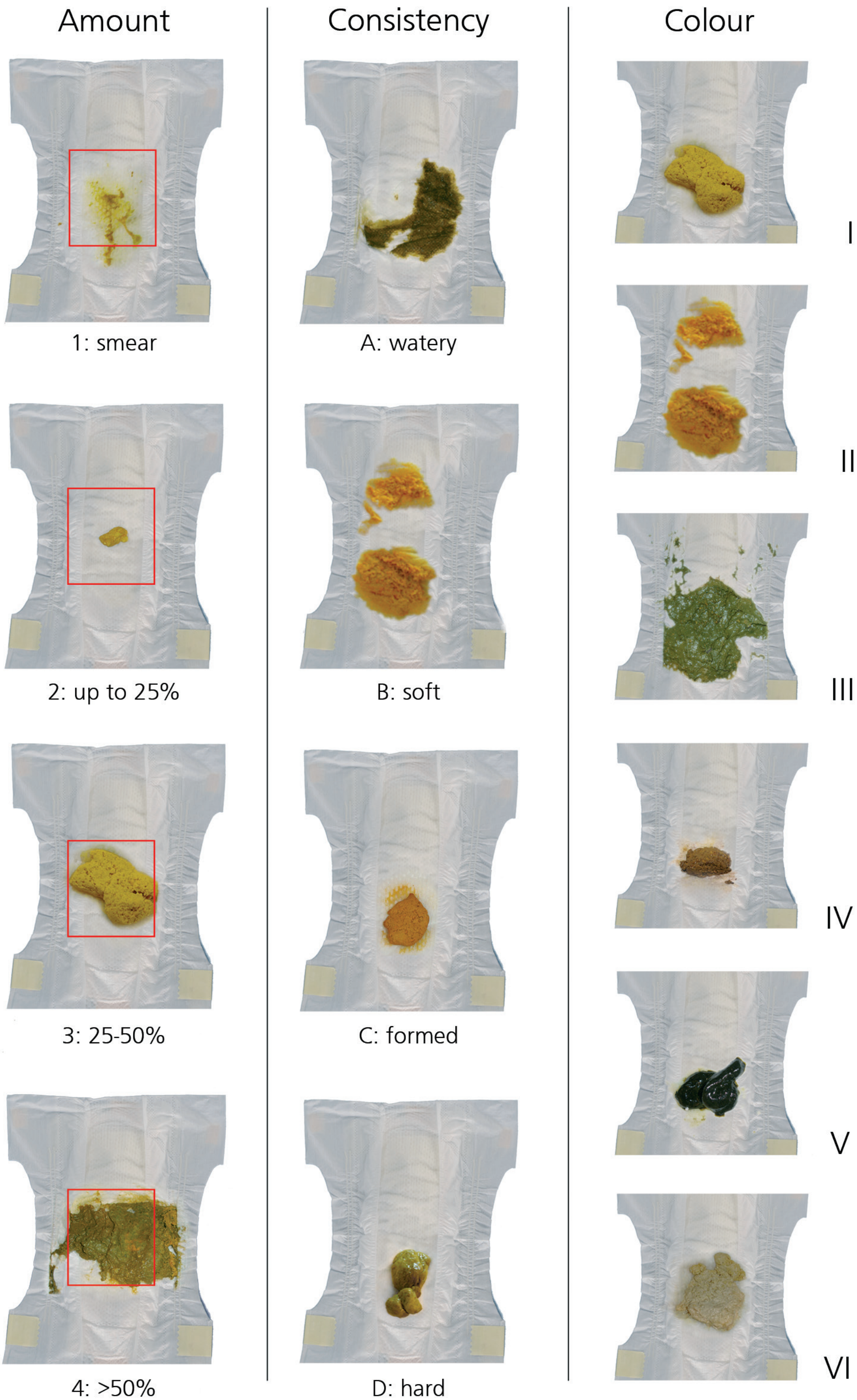

Figure 2. The newly developed infant stool form scale

Table 2. Amount of stools of BF infants and FF infants

	Consistency				Amount			
	A	B	C	D	I	II	III	IV
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
BF	6 (6)	60 (57)	33 (31)	7 (7)	5 (5)	52 (49)	44 (42)	5 (5)
FF	4 (2)	160 (68)	64 (27)	9 (4)	0	99 (41)	93 (39)	45 (19)
BF+FF	3 (2)	112 (55)	81 (39)	9 (4)	2 (1)	84 (41)	97 (47)	22 (11)
NEF	1 (14)	4 (57)	1 (14)	1 (14)	0	0	4 (57)	3 (43)

simple k value of 0.85 (0.79 to 0.91) for colour for observer I, whereas observer II had a weighed k value of 0.90 (0.87 to 0.93) and 0.94 (0.92 to 0.96) for respectively consistency and amount; and simple k value 0.92 (0.90 to 0.95) for colour.

Stool characteristics in relation to gestational age

No differences in consistency (p=0.27), amount (p=0.68) and colour (p=0.25) were found between preterm and term born infants. Furthermore, no difference in stool characteristics was found between the premature infants from different gestational age groups (table 1).

Stool characteristics in relation to type of feeding

Stool consistency differences between BF and FF infants did not reach statistical significance (p=0.07). However, amount of stools produced by FF infants was

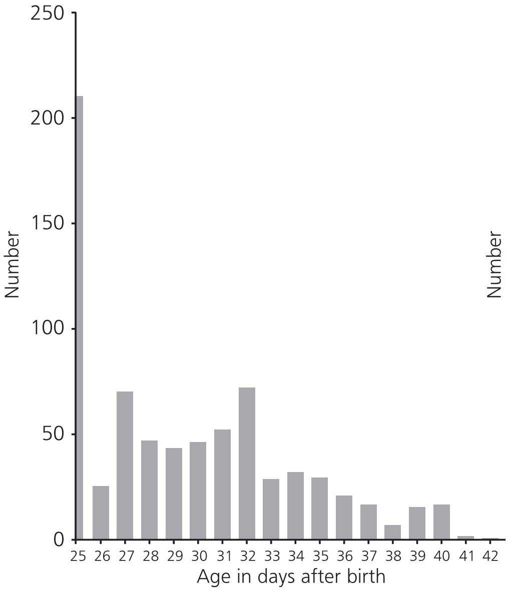

Figure 4. Distribution of GA of participating infants.

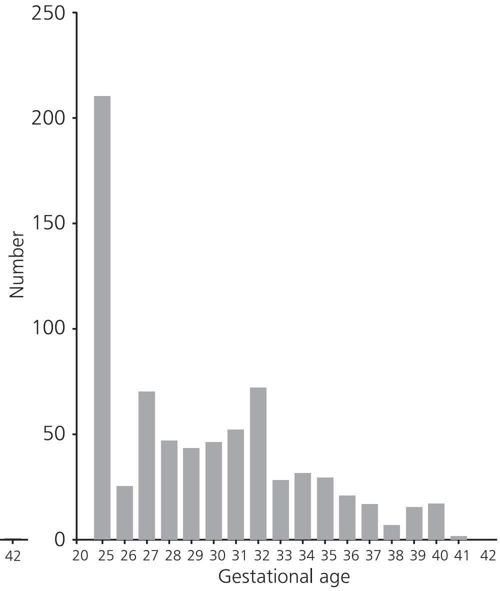

Figure 3. Number of stool images in relation to the age in days after birth.

Colour					
Meconium	Yellow	Orange	Green	Brown	Clay
n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
21 (20)	37 (35)	34 (32)	7 (7)	7 (7)	0
37 (16)	88 (37)	89 (38)	12 (5)	8 (3)	3 (1)
8 (4)	117 (57)	49 (24)	14 (7)	13 (6)	4 (2)
5 (71)	1 (14)	1 (14)	0	0	0

significantly larger compared to the BF infants ($p<0.001$) (table 2). Colour was not different between BF and FF infants ($p=0.43$).

Impact of ageing on stool characteristics

With increasing age, consistency of stools changed into harder stools ($p<0.001$). Sixty six percent of infants younger than 16 days (group I) had soft stools compared to 54% from group II and 58% from group III. Formed stools were found in only 26% of infants from age group I compared to 41% and 35% in respectively age groups II and III.

Furthermore, with increasing age the amount of stools alters into larger stools ($p<0.001$). Larger stools (amounts III and IV) were found in 47% of infants from group I compared with 60% and 71% of infants in age group III and IV ($p<0.001$).

In addition, the colour of stool changed with age ($p<0.001$) as well. The most common colour found in age group I was brown (38%) and meconium (28%), compared to yellow (29%) and brown (60%) in group II and yellow (50%) and brown (37%) in group III.

DISCUSSION

On the basis of the analysis of more than 500 digital infant stool photographs, we were able to develop the first stool form scale for premature and term born infants aged up to 120 days after birth. Validity of this scale was supported by the good to excellent interobserver and intraobserver agreement scores. With this stool scale, no difference was found in stool characteristics between preterm and term born infants. Significant differences in stool amount were found between BF and FF infants, but not in consistency and colour.

A Japanese chart for infant and children's stools describing stools in gastro-intestinal conditions such as diarrhoea and biliary atresia exists. [11] However, these photographs were mainly based on only 1 patient per condition. Furthermore, we evaluated the amount of stool by determining the percentage diaper surface filled up by stool. Although the surface of diapers may differ between different regions in the world, in general newborn infants wear the same size of diapers depending on the child's weight. For this reason, we believe that describing the amount by estimating the percentage of the total surface is reliable for describing amount in practice. Description of amount in ml rather than surface is more adequate but also more difficult for both parents and clinicians, because they do not usually weigh the stools. Moreover, weighing stools might be time consuming and, hence, not practical.

An infant stool form scale should at least include consistency, amount and colour. For consistency, we chose watery, soft, formed and hard as physicians and parents describe infant stool consistencies in these terms. For describing amount, we chose for example smear (score 1) as indeed parents usually describe this phenomenon in their constipated child who is failing to defecate. By only describing amount and consistency the scale would still lack information about stool colours. Stool colours such as green might concern parents and therefore visualising those colours in the scales would reassure them. By coverage of those 3 stool aspects (consistency, amount & colour), we aimed for content validity of our stool scale. Content validity means whether the scale covers all aspects which have to be measured. [7] Furthermore, we found good interobserver and excellent intraobserver agreement using this infant stool form scale. The agreement between the 2 observers was good for all items. In several studies from other disciplines evaluating interobserver variability, in clinically applicable tools, for example, interpretation of mammograms or assessment of carotid plaques, moderate to good agreement findings are found acceptable. [12, 13] Davies et al reported a close correlation between subject reported and an independent observer reported stool form evaluation (r = 0.93). [14] These preliminary results indicate that this scale could be a useful addition in daily practice to monitor changes in stool characteristics.

In contrast to other studies, in which breastfed infants had mainly pasty and larger stools compared to stools of formula fed infants, we did not find significant differences in stool consistency between those 2 groups. [15-17] Because 90% of the infants were premature born, an immature colon with yet lower water holding capacity may have contributed to similar consistencies of stools of both BF and FF infants. [18] Another possible explanation might be the supplementation of galacto- and fructo-oligosaccharides in formula feeding which are currently commonly added to infant formula. [19] Supplementation of the latter products may result in looser stool consistency comparable to BF infants. [20] Unfortunately, we did not collect data concerning the exact type of formula feeding.

In contrast to the findings of Weaver et al., we found that BF infants passed more frequent and smaller amounts of stools compared to FF infants. [21] A possible explanation might be that we defined amount by using an infant stool form scale based on pictures of infant stools in a diaper rather than the commonly used 3-dimensional illustration model. Furthermore, Weaver et al. used a 3-points scale recorded by nurses while we used a 4-points scale scored from diaper pictures making those results difficult to compare. [22, 23] Because BF infants defecate more than FF infants one would expect those groups to produce comparable total amounts of stool per day as they ingest comparable amount of feeding (ml) per day. Consequently, BF infants would produce smaller amounts of stools as they defecate more frequently.

Comparable to other studies, with aging the frequency of harder stools increased, reflecting maturation of the water conserving capacity of the gut. [24-26] This is illustrated by rat models where permeability of the colon, not only to water and electrolytes, is increased in the weaning compared to the adult rats. [27]

One limitation of our study is that our newly developed scale does not have criterion validity for consistency and amount as we described those characteristics upon consent between 2 observers. The observers chose typical pictures for each type of consistency based on appearance. Furthermore, and in contrast with adult studies we were not able to correlate colonic transit time with our infant stool form scale. (13) The medical ethical board of our hospital, however, gave no permission to use carmine red to evaluate colonic transit times in premature infants. Further studies using this new tool are needed to confirm our findings and to relate colonic transit times to stool characteristics in infants.

In conclusion, the newly developed “Amsterdam” infant stool scale enables parents and clinicians to reliably rate different aspects of stools, such as consistency, amount and colour of premature and term infants. This scale might be helpful in differentiating between normal and abnormal defecation patterns in infants. Therefore, future studies are necessary validating the applicability and validity of this scale for practical and research purposes.

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