Infant Stool Form Scale: Development and Results

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Objective To develop an infant stool scale describing consistency, amount, and color 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.

Study design 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 color (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 analyzed; 60 (11%) of the infants studied were term, and 495 (89%) were born prematurely. No differences were found between preterm and term infants. Breastfed infants had smaller amounts of stools compared with formula-fed infants ($P < .001$). The interobserver weighed κ value (95% CI) was good for consistency and amount; the simple κ value was good for color. For observers I and II intraobserver κ values were excellent.

Conclusion This "Amsterdam" stool form scale is useful to assess defecation patterns in both premature and term born infants. *(J Pediatr 2008;xx:xxx)*

A stool form scale describing stool characteristics such as consistency, amount and color of feces in infants has not been 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) whereas 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 epidemiologic 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, diarrhea, 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 pathologic 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

BF	Breast fed	FF	Formula fed
BSFS	Bristol Stool Form Scale	GA	Gestational age

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(zoom lens, original magnification × 4 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 feces 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 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 (99 cm^2) was the reference surface area (Figure 1; available at www.jpeds.com). Then 4 typical photographs were chosen upon consensus by the 2 observers to describe the amount into: "smear," <25%, 25% to 50%, and >50% of feces in the reference area. To classify color, 6 photographs were chosen illustrating the colors yellow, orange, green, brown, meconium, and clay-colored. These typical photographs (n = 14 pictures) describing the different categories of consistency, amount and color 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 color. 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 analyze of 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 GA and Type of Feeding

For these analyses, a consensus reading for all stool aspects was constructed on the basis of consensus classification by the 2 observers. Premature infants were divided into 3 groups according to their GA in weeks; group 1: AD ≤ 28 weeks; group 2: 29 ≥ AD ≤ 32 and group 3: 33 ≥ AD ≤ 36. For evaluation of differences in stool characteristics between young and older infants 3 age groups were selected on the basis of the percentiles of the total age (in days after birth) of all participating infants. Group I were infants 15 days of age and younger (25th percentile), group II consisted of infants older than 15 days and younger than 30 days (25-75th percentile), and group 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 Analysis

The number of photographs of stools and infant characteristics like GA, age in days after birth, and type of feeding were analyzed in a descriptive way. The interobserver and intraobserver variability were evaluated by calculating the proportion of exact agreement and the κ statistics for nominal data (color) and weighted κ values (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 (κ), was categorized, as described by Altman, as poor ($\kappa \leq 0.2$), fair ($0.21 \leq \kappa \leq 0.40$), moderate ($0.41 \leq \kappa \leq 0.60$), good ($0.61 \leq \kappa \leq 0.80$) or excellent ($0.81 \leq \kappa \leq 1.00$).[9]

The Mann-Whitney test was used to examine differences in stool consistency, amount and color between premature and term born infants and between BF and FF infants. Ordinal regression analyses were performed to evaluate the difference in stool consistency; amount and color (when ranged ordinal from dark to light colors) with time divided over 3 age groups. All analyses were performed with SPSS statistical software (SPSS Inc.14.0.2, Chicago, Illinois). All *P* values less than .05 were considered statistically significant.

RESULTS

Baseline Characteristics

A total of 907 digital photographs of infant stools were taken of which 555 could be analyzed. 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 analyzed (Figure 3 and Figure 4; available at www.jpeds.com). Sixty of the participating infants (11%) were term born. Of the premature born infants, 166 (30%) were born ≤28 weeks gestation; 217 (39%) between 29 and 32 weeks and 112 (20%) between 33 and 36 weeks; 106 infants (19%) received BF and 237 (43%) were FF, and 205 infants (37%) were simultaneously BF and FF. Seven infants (1%) did not receive enteral feeding.

Infant Stool Form Scale

The final scale describing consistency (ordered categories), amount (ordered categories), and color 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 color. 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 color.

The interobserver weighed κ value (95% CI) was 0.68 (0.62 to 0.74) for consistency, 0.74 (0.69 to 0.78) for amount,

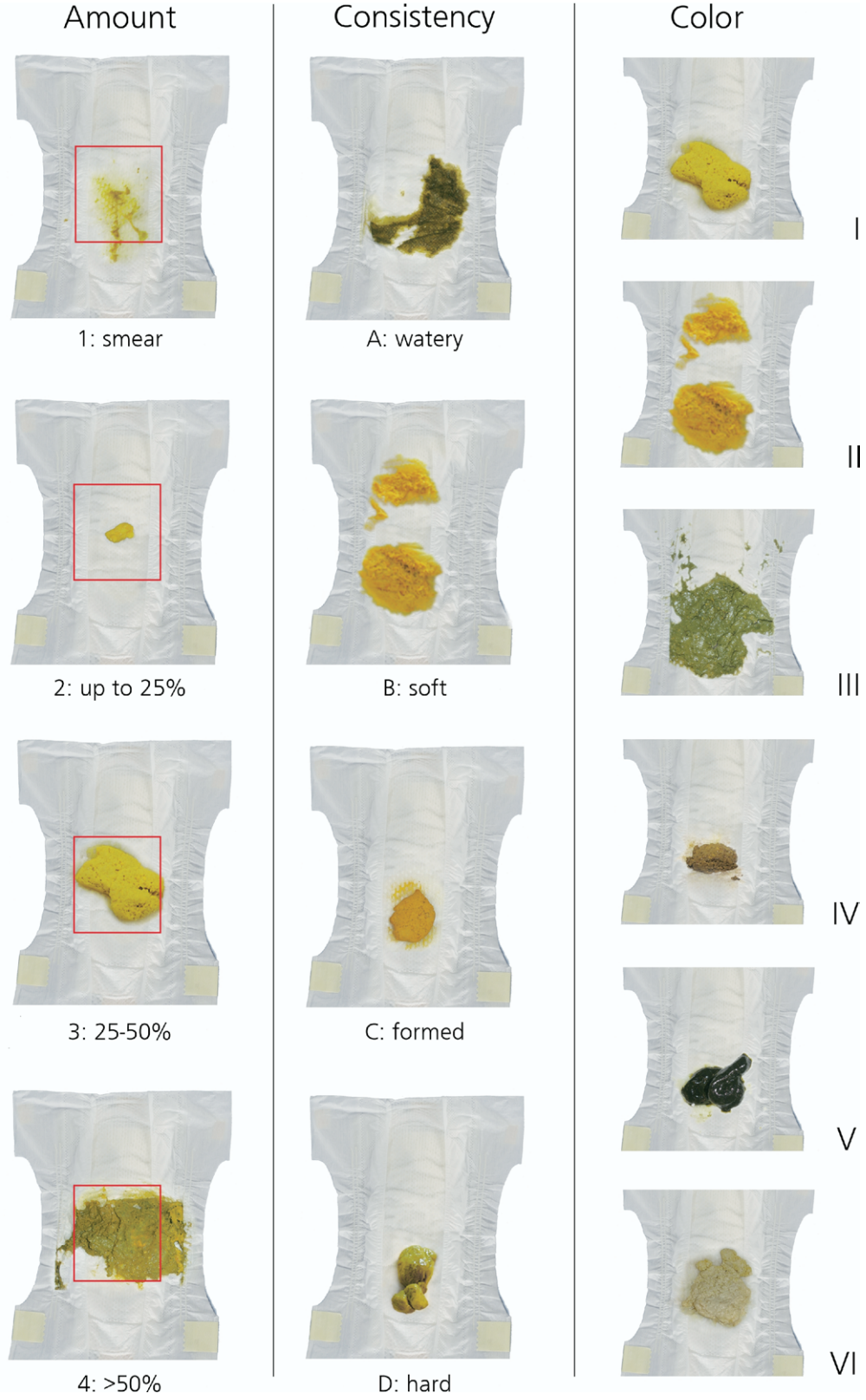

Figure 2. The newly developed infant stool form scale.

and simple κ value of 0.75 (0.70 to 0.79) for color. After 3 months, the observers scored the same photographs, again showing an excellent intraobserver agreement. The intraobserver weighed κ value was 0.84 (0.75 to 0.93) and 0.89 (0.83 to 0.94) for respectively consistency and amount; and simple κ value of 0.85 (0.79 to 0.91) for color for observer I, whereas

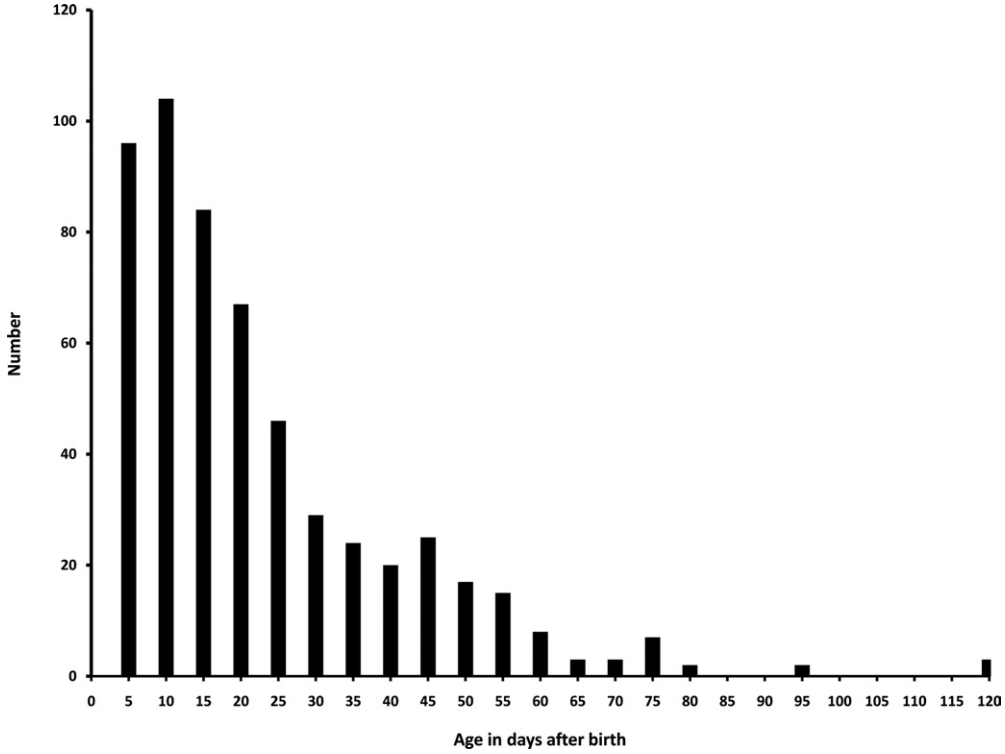

Figure 3. Number of stool images in relation to the age in days after birth.

observer II had a weighed κ value of 0.90 (0.87 to 0.93) and 0.94 (0.92 to 0.96) for, respectively, consistency, and amount; and simple κ value 0.92 (0.90 to 0.95) for color.

Stool Characteristics in Relation to GA

No differences in consistency ($P = 0.27$), amount ($P = 0.68$) and color ($P = 0.25$) 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 I).

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 significantly larger compared with the BF infants ($P < .001$) (Table II). Color was not different between BF and FF infants ($P = .43$).

Impact of Aging on Stool Characteristics

With increasing age, consistency of stools changed into harder stools ($P < .001$). Sixty-six percent of infants younger than 16 days (group I) had soft stools compared with 54% from group II and 58% from group III. Formed stools were found in only 26% of infants from age group I compared with 41% and 35% in, respectively, age groups II and III.

Furthermore, with increasing age the amount of stools alters into larger stools ($P < .001$). 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 ($P < .001$).

In addition, the color of stool changed with age ($P < .001$) as well. The most common color found in age group I was brown (38%) and meconium (28%), compared with 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 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 color.

A Japanese chart for infant and children's stools describing stools in gastrointestinal conditions such as diarrhea 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

Table I. 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
Color					
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 colored	2	2	2	1	7

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

	Consistency				Amount				Color					
	A	B	C	D	I	II	III	IV	Mec	Yellow	Orange	Green	Brown	Clay
BF	6 (6)	60 (57)	33 (31)	7 (7)	5 (5%)	52 (49%)	44 (42%)	5 (5%)	21 (20%)	37 (35%)	34 (32%)	7 (7%)	7 (7%)	0
FF	4 (2)	160 (68)	64 (27)	9 (4)	0	99 (41%)	93 (39%)	45 (19%)	37 (16%)	88 (37%)	89 (38%)	12 (5%)	8 (3%)	3 (1%)
BF + FF	3 (2)	112 (55)	81 (39)	9 (4%)	2 (1%)	84 (41%)	97 (47%)	22 (11%)	8 (4%)	117 (57%)	49 (24%)	14 (7%)	13 (6%)	4 (2%)
NEF	1 (14)	4 (57)	1 (14%)	1 (14%)	0	0	4 (57%)	3 (43%)	5 (71%)	1 (14%)	1 (14%)	0	0	0

Mec, Meconium; *NEF*, no enteral feeding.

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 color. 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 colors. Stool colors such as green might concern parents and therefore visualizing those colors in the scales would reassure them. By coverage of those 3 stool aspects (consistency, amount, and color), we aimed for content validity of our stool scale. Content validity means whether the scale covers all aspects that 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[14] reported a close correlation between subject reported and an independent observer reported stool form evaluation (r = 0.93). 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 with stools of FF 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.[17] Another possible explanation might be the supplementation of galactooligosaccharides and fructooligosaccharides in formula feeding, which are currently commonly added to infant formula.[18] Supplementation of the latter products may result in looser stool consistency comparable to BF infants.[19] Unfortunately, we did not collect data concerning the exact type of formula feeding.

In contrast to the findings of Weaver et al,[16] we found that BF infants passed frequent and smaller amounts of stools compared with FF infants. A possible explanation might be that we defined amount by using an infant stool form scale on the basis of pictures of infant stools in a diaper rather than the commonly used 3-dimensional illustration model. Further-

more, Weaver et al[16] used a 3-point scale recorded by nurses while we used a 4-point scale scored from diaper pictures making those results difficult to compare.[16,17] 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 because they defecate more frequently.

Comparable with other studies, with aging the frequency of harder stools increased, reflecting maturation of the water conserving capacity of the gut.[15,16,20] This is illustrated by rat models where permeability of the colon, not only to water and electrolytes, is increased in the weaning compared with the adult rats.[21]

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 on the basis of 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 with 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 color 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 to validate the applicability and validity of this scale for practical and research purposes.

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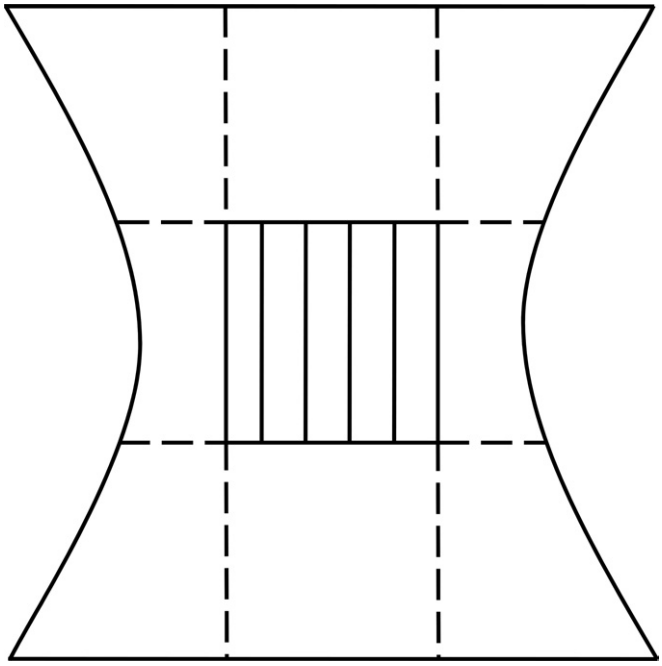

Figure 1. *Hatched quadrangle*: reference surface for defining the scales for the amount of stools.

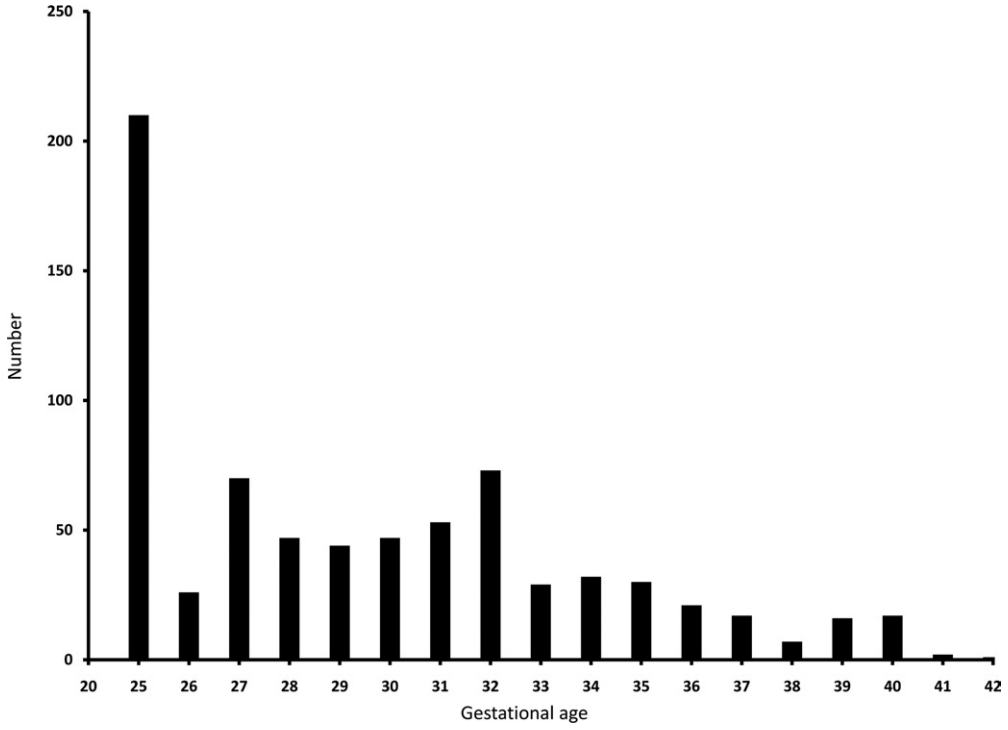

Figure 4. Distribution of GA of participating infants.