A Danish reference chart for assessment of psychomotor development based on the Ages & Stages Questionnaire

Katrine Kure Østergaard, Ane Vibeke Lando, Bo Mølholm Hansen & Gorm Greisen

ABSTRACT

INTRODUCTION: The aim of this study was to obtain Ages and Stages Questionnaire (ASQ) scores from the background population so that these may be used as a reference group to extremely preterm children at nine and 18 months of corrected age.

MATERIAL AND METHODS: A total of 298 children were randomly chosen among the Danish population in three different groups: 9-, 18- and 21 month-old children. The parents received the 10-month ASQ when their child had reached a corrected age of nine months and the 24-month ASQ questionnaire when their child had reached the corrected age of 18 or 21 months.

RESULTS: The total scores were normally distributed in both groups. There was a highly significant ($p < 0.001$) linear regression between ASQ total score and adjusted age for both the 10- and the 24-month ASQ.

The regressions can be summarized by the following formulas:

10-month ASQ:

$$\text{Z-score} = \frac{\text{ASQ total} - (-0.87 + 22.3 \times \text{adjusted age in months})}{35.5}$$

24-month ASQ:

$$\text{Z-score} = \frac{\text{ASQ total} - (-91.2 + 14.7 \times \text{adjusted age in months})}{32}$$

CONCLUSION: The results of the study show that the overall development can be assessed when the child is scored with an ASQ intended for older children. Screening for developmental delay in children in the age range of 8-10 months or 18-22 can be quickly assessed by reference to a chart. The chart can also be used as a reference when monitoring the quality in neonatal services by the developmental outcome and this ensures that children are classified according to Danish standards.

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The improved survival of preterm infants during the past decades [1] has made it imperative to focus on outcome as many preterm babies have neurodevelopmental deficits. The most immature infants born before 28 weeks of gestation (extremely preterm infants) are of particular concern. Studies have found that up to 50% of these infants may have some kind of neurodevelopmental deficit [2, 3]. It is therefore important to monitor the development of extremely preterm children, so that treatment and interventions can be followed. New methods for the evaluation of child development that are simple, less time-consuming and less expensive than previously are increasingly being used. The parent-completed Ages and Stages Questionnaire (ASQ) has been proven a cost-effective and reliable method for assessing children with developmental delays [4] and has been validated in many countries [5-9]. The ASQ is designed to identify children who have developmental delays, but it has also been used to evaluate the overall development in high-risk children [10]. The ASQ has been translated into Danish and is used as part of the follow-up in extremely preterm born children at the Department of Neonatology, Rigshospitalet, Copenhagen [11].

The aim of this study was to obtain ASQ scores from the background population so that these may be used as a reference when assessing extremely preterm children at nine and 18 months of corrected age.

MATERIAL AND METHODS

A total of 298 children were randomly chosen from the Danish population to be included in the study. In all, 100 children were included in the group of 9 month-old children, and 198 in the 18- and 21 month-old groups. The 198 children were divided into the 18- and 21 month-old groups, respectively, by a random sequence generator. The randomisation sequence was computer-generated by the Danish Central Office of Civil Registration (CPR Office). The addresses of the 298 children were obtained from the CPR Office. Information about their gestational age, Apgar score, multiple births (single, twins or triplets) and if Caesarean section had been performed was obtained from the Danish Birth Register.

The parents were subsequently mailed the ASQ along with an explanatory letter, a health questionnaire and a questionnaire on the mother's educational level.

Parents received the 10-month ASQ when their child had reached the corrected age of nine months, and the 24-month ASQ questionnaire when their child had

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Department of Neonatology, Juliane Marie Centre, Rigshospitalet

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reached the corrected age of 18 or 21 months, respectively. If they did not respond, telephone calls were made reminding them to submit the ASQ.

There is an ASQ for 19 different ages (4-60 months). The questionnaire consists of six questions in each of the following five areas of development: communication, gross motor skills, fine motor skills, problem solving and personal-social. The answer options are "yes" (ten points), "sometimes" (five points) or "not yet" (zero points), resulting in a maximum score of 300 points. If an answer was missing, the average score for each question was calculated (total score of answered questions divided by the number of answered questions) and added to the total score of the area.

If a questionnaire was returned without a date of completion, we used the median number of days from the ASQ was received by the parents until it was answered for those who returned the ASQ before the first phone reminder call was made. To calculate the missing dates of completion we added the median to the day the ASQ was received.

The educational level of the mother was scored: School education on a six-point scale and vocational training on a five-point scale. The two scores were added which yielded a total score ranging from 2-11. The total scores of the mothers' educational levels were divided as follows: category 1: 2-7.5 points; category 2: 8-9.5 points; category 3: 10-11 points.

TABLE 1

Participant data and scores of the three groups.

	9 month-old	18 month-old	21 month-old
Participants, n	64	65[a]	58[b]
Gestational age at birth, mean ± SD (range), days	279 ± 15 (214-294)	278 ± 17 (209-295)	277 ± 14 (215-296)
Birth weight, mean ± SD, g	3,613 ± 708	3,454 ± 722	3,462 ± 588
Apgar score, mean ± SD	9.9 ± 0.4	9.9 ± 0.3	9.9 ± 0.2
Singleton, % (n)	100 (63)	94 (61)	97 (56)
Female, % (n)	48 (31)	40 (26)	48 (28)
Caesarean section, % (n)	14 (9)	29 (19)	12 (7)
Living in Eastern Denmark, % (n)	47 (30)	42 (27)	43 (25)
Age, mean ± SD (range), months	9.3 ± 1 (7.5-13)	19.5 ± 1.2 (16.9-23.5)	21.7 ± 1.6 (19.6-25.8)
Total score, mean ± SD (range), SEM	207 ± 41 (105-290), 5.0	193.4 ± 41 (105-280), 5.0	230.3 ± 34.3 (140-290), 4.5
Total score, gender, mean ± SD			
Girls	204 ± 40	202 ± 29.4	234.3 ± 28.3
Boys	209 ± 42	185.8 ± 43	217.5 ± 34.1
Total score, geography, mean ± SD			
East	213 ± 44	199.5 ± 35	223.4 ± 34.5
West	201 ± 38	187 ± 40.8	226 ± 31.1

SD = standard deviation; SEM = standard error of mean.
a) Gestational age and birth weight were missing for 1 child; Apgar score was missing for 2 children.
b) The following data were missing for 1 child: gestational age, birth weight, Apgar score, Caesarean section.

Statistical analyses were performed using SPSS statistics, version 17.0.

Histograms were made for ASQ total score. Mean, median and standard deviation (SD) were calculated. Linear regressions were performed on ASQ total score and adjusted age to evaluate the association between age and ASQ score. The regressions were performed for two groups: the 9 month-old children who were assessed by the 10-month questionnaire and the 18- and 21 month-old children who were assessed by the 24-month questionnaire. The effect of parents' education was also investigated by including the mothers' educational levels into these regression analyses.

Second polynomial regressions were performed to investigate whether there was a statistically significant deviation from a linear association between the ASQ scores and the children's age in the whole spectrum of the ages.

The T test was used to compare parametric data and the χ^2 test to compare categorical data.

The Danish data protection agency approved the study (no. 2009-41-3063).

Trial registration: not relevant.

RESULTS

The response rate was 64%, 59% and 66%, respectively, in the three groups of children. **Table 1** summarizes data from participants/responders and non-responders. There were no significant differences between non-responders and participants ($p > 0.05$) concerning birth weight, gestational age and Apgar score, nor between singletons versus twins, females versus males, or children living in Eastern versus Western Denmark. Caesarean section for the 9 month-old children displayed a marginally significant difference between responders and non-responders (Pearson $\chi^2 = 0.023$), but this is considered a mass-significance effect.

One child was excluded from the 21-month group because of a total score of ten points. No questionnaire contained more than one missing answer of the total of 30 questions.

The total score of all three groups showed a normal distribution; neither skewness nor kurtosis differed significantly from the normal distribution (data not shown).

There was a highly significant ($p < 0.001$) linear correlation between the ASQ total score and the adjusted age for both questionnaires (**Figure 1** and **Figure 2**). The 24-month questionnaire demonstrated some non-linearity ($p = 0.03$) confirming the visual impression of a slight downwards skewness in the ASQ values for the children older than 22 months.

The regressions can be summarized in the following formulas:

10-month ASQ:

$$\text{Z-score} = \frac{\text{ASQ total} - (-0.87 + 22.3 \times \text{adjusted age in months})}{35.5}$$

35.5 is the SD of the residuals. Thus, when the age increases with one month, the ASQ score increases with 22.3 ± 4.4 points. The correlation coefficient is 0.54, i.e. 29.6% of the variation in the total score can be explained by age.

24-month ASQ:

$$\text{Z-score} = \frac{\text{ASQ total} - (-91.2 + 14.7 \times \text{adjusted age in months})}{32}$$

32 is the SD of the residuals. Thus, when the age increases with one month, the ASQ score increases with 14.7 ± 1.6 points. The correlation coefficient is 0.61, i.e. 37.6% of the variation in the total score can be explained by age.

The residuals were also normally distributed.

Linear regression between ASQ total score and maternal educational level showed no significant association for either of the groups.

FIGURE 1

10-month Ages and Stages Questionnaire, linear regression with 95% confidence interval. Use is only recommended in the age interval from eight to ten months (adjusted to term birth).

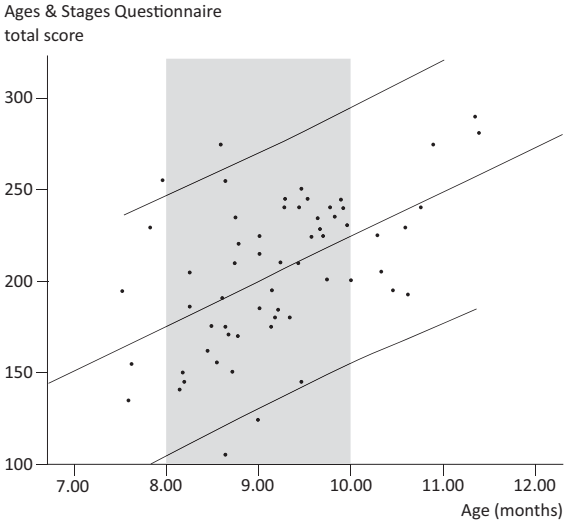
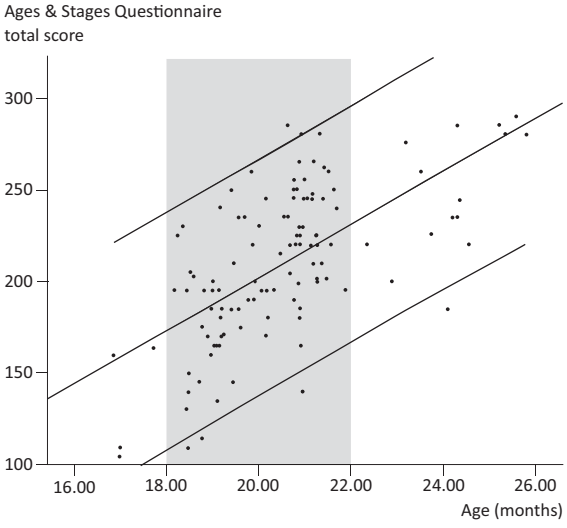


FIGURE 2

24-month Ages and Stages Questionnaire, linear regression with 95% confidence interval. Use is only recommended in the age interval from 18 to 22 months (adjusted to term birth).



DISCUSSION

The study shows that there is a significant linear association between age and ASQ score: the scores increased with increasing age of the children when using the 10-month ASQ as well as the 24-month questionnaire. This was expected and supports the usefulness of the questionnaire.

In this study, we used an ASQ questionnaire that was designed for older children. We did this to allow the best functioning children to be appropriately represented. If a child achieves a result (near) the maximum score of 300, then it is possible that the child could have achieved even more, if more difficult tasks had been part of the test. This is the normal procedure in face-to-face developmental tests, but since the ASQ test is designed to screen for developmental delay, many children will score near the maximum if the test is given at the age recommended in the manual. In our study, we obtained a normal distribution of total scores – enabling calculation of group means. This makes the test suitable for evaluation of the group mean of a population of children treated in the neonatal period, e.g. for extreme prematurity or for severe birth asphyxia, and it can therefore serve as a measure of quality of the service provided.

The ASQ in the English version has been validated and compared to Griffith Mental Development Scale, Bayley Mental Development Intelligence Scale and McCarthy General Cognitive Intelligence Scale [7]. In 2004 the questionnaire for 48 month-old children was translated into Danish, validated and compared with the Wechsler Preschool and Primary Scale of Intelligence-Revised (WPPSI-R) by Klamer et al with a fairly good result [11]. Finally, the ASQ has been translated into languages such as Norwegian, Dutch, Hindi and Thai and used on a large scale [6, 12-14]. We therefore found it reasonable to use the ten and 24-month ASQ without further validation.

We gave the 24-month ASQ questionnaire to 18- as

well as to 21 month-old infants (corrected age) to see if there was any difference in response rate. A more difficult questionnaire might discourage parents to answer. We found no evidence of this. We merged the two groups because there was an overlap in ages in the 18- and 21-month groups and in order to increase the statistical power of our analysis.

Our data showed a small degree of non-linearity. As predicted, this appeared to be caused by a lack of values above the predicted mean when the age passes 22 months. Thus, it seems that at above 22 months of age, the 24-month ASQ cannot be used as a developmental test. Furthermore, we did not have sufficient data points for 22 months and above to obtain reliable estimates of the statistical distribution at such age. For the 10-month questionnaire, there was apparently no such nonlinearity, but again there were only few data points at 11 month and above.

In Figure 1 and Figure 2, we have plotted the mean and the ± 2 SD range. It is seen that the + 2 SD line approaches the maximum score of 300 at the upper age limit. Thus, the age ranges where we have found that the ASQ is useful for group use as well as individual use is 8-10 months for the 10-month questionnaire and 18-22 months for the and 24-month questionnaire.

It is important to note that the correction for the precise age at testing is important. Psychomotor development is fast at these ages: As the age increases with one month, the score increases with what corresponds to approximately 0.5 SD. In practical use, this means that if a child tests marginally low, it may be useful to repeat after two months with the same questionnaire to evaluate progress in development.

The mother's educational level was not shown to have an influence on the total score. Previous findings show that children of mothers with a low educational level have more behavioural problems and have a lower developmental quotient than other children [15]. One might therefore expect the educational level of the mother to have an influence on her child's ASQ total score. This was not seen in our study and this may be because ASQ has considerable focus on motor development. There was no correlation between late responders and the mother's educational level.

A strength of the study is that it uses a randomly selected sample of the Danish population, assessed at the same time. A sample of 298 unselected children was chosen.

Previous studies have found an SD of approximately 39, and we expected to find an SD close to this value. With 100 children in each group, we expected a standard error of the mean (SEM) ~ 3.9. This is an acceptable uncertainty compared with the SD.

A weakness is that the response rate was only 64%, 59% and 66%, respectively; however, we still achieved relatively small SEMs of 5.5 and 4.5. We found no indication of a selection bias, but clearly this cannot be excluded.

The results found in this study correlate well with previous results found in a reference group by Plomgaard et al [10]. Their study yielded a mean ± SD of 224 ± 39. Comparing this result to ours by a two-sample t-test demonstrates that there is no significant difference between the studies ($p > 0.1$).

CONCLUSION

Overall development can be assessed when the child is scored with an ASQ meant for older children. To assess the development of children covering the age range of 8-10 months or 18-22 months, the ASQ score can be directly plotted on Figure 1 or Figure 2 This provides a quick method for assessing developmental delays which may be valuable when high-risk children are followed in out-patient clinics where the access to formalised testing, e.g. Bailey Scales of Infant Development, is restricted.

The chart can also be used as a reference by plotting the mean of a group and hereby comparing it to a representative sample of Danish children. This may be relevant for quality control of neonatal services and may be used as a complement to mortality statistics.

CORRESPONDENCE: *Ane Vibeke Lando*, Neonatalklinikken, Rigshospitalet, Blegdamsvej 9, 2100 Copenhagen, Denmark. E-mail: d233455@dadlnet.dk

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