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Early Development of Preterm Infants: Use of the Neurobehavioral Assessment of the Preterm Infant (NAPI)

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Abstract: In search of an instrument that could measure the differential maturity of neurobehavioral development in preterm infants, thirty three preterm infants were assessed using the Neurobehavioral Assessment of the Preterm Infant (NAPI) at 36 weeks conceptional age. Simultaneously, a neurological examination was carried out. At 3 months corrected age, neurological and psychological examinations were again made.

During the NAPI examinations, the infants were mostly in alert state at least half the time. The majority of infants were capable to respond to auditory and visual stimuli by shifting eyes to sound, focusing on and following visual stimulus for at least 30°. Partial to complete forearm recoil, mean extension of the infant's neck, trunk, and tighs, brief prone head lifting, moderate power of active movements, and moderate vigor of spontaneous movements were characteristic.

The NAPI assessment at 36 weeks conceptional age correlated with the neurological assessment at the same age, and with later neurological and psychological findings: three NAPI functional domains (Motor development and vigor, Alertness and orientation, Irritability) were related to the neurological and psychological status at 3 months corrected age.

High responsivity and favourable state, high agreement with the neurological examination and with later neurological and psychological evaluation lead us to the conclusion that the NAPI is a valuable method for assessing the early phases of neurobehavioral development in preterm infants. Thus, data on current neurobehavioral functioning revealed by the NAPI may serve as an appropriate basis for the establishment of an individual infant-oriented program.

Resumo: *Desenvolvimento dos bebês pretermos: uso da Avaliação Neurocomportamental da Criança Pretermo (NAPI).* O objetivo deste artigo foi medir diferenças na maturidade do desenvolvimento neurocomportamental de trinta e três pretermos com 36 semanas de idade posnatal, usando a Avaliação Neurocomportamental da Criança Pretermo (NAPI).

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Uma avaliação neurológica foi também usada, simultaneamente. Avaliações psicológica e neurológica foram feitas também aos 3 meses de idade corrigida.

Durante o exame com a NAPI, as crianças estavam pelo menos a metade do tempo acordadas. A maioria das crianças foi capaz de responder aos estímulos auditivos e visual, virando os olhos na direção do som, focalizando e acompanhando o estímulo visual até pelo menos 30°. Outros items tais como recolhimento parcial ou completo do ante-braço, média de extensão do pescoço, tronco, cochas, breve levantamento da cabeça em posição prono, força moderada dos movimentos ativos e vigor moderado dos movimentos espontâneos, foram característicos da idade.

Existe uma correlação entre a avaliação NAPI com 36 semanas de idade posnatal e o exame neurológico na mesma idade, bem como daquela com as avaliações neurológica e psicológica,posteriormente; três domínios funcionais da NAPI (desenvolvimento Motor e vigor, estado de alerta e orientacão e irritabilidade) se correlacionaram com o status neurológico e psicológico aos 3 meses de idade corrigida.

Os resultados demonstrando o estado favorável, a alta incidência de resposta, correlação com os exames neurológico e psicológico, sugerem que a NAPI é um método válido para a avaliação das fases iniciais do desenvolvimento neurocomportamental da criança pretermo. Portanto, os dados sobre o funcionamento neurocomportamental atual da criança, revelados pelo exame com a NAPI, sugerem que este exame poderá ser usado com sucesso para se estabelecer um programa individualizado.

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Introduction

Preterm infants are at increased risk for abnormal development. Reviews summarizing outcomes (Aylward et al. 1989; Ornstein et al. 1991) indicate that neurological and psychological impairments occur in this at-risk population. Moreover, preterm birth may not only affect the course of an infant's neuropsychological development but also may act unfavourably on the psycho-social climate of the family (Friedman et al. 1981; Minde et al. 1983; Levy-Shift et al. 1989; Stjernquist 1992; Wulfften Palthe et al. 1993; Nordström-Erlandson 1996; Sobotková et al. 1996a; Taanila et al. 1996).

Various intervention programs were developed to prevent the disabilities of the preterm infant as well as the problems in parent-preterm infant interactions (McCarton et al. 1996). To evaluate the effects of an intervention, the assessment of the functional maturity in each individual infant is necessary.

In search of an instrument that could measure the differential maturity of neurobehavioral development in preterm infants who participated in our intervention study (Sobotková et al. 1996b), we considered using the Korner and Thom Neurobehavioral Assessment of the Preterm Infant (NAPI, Korner et al. 1990). This method was developed for longitudinal assessment of the neurobehavioral development of very young preterm infants, from 32 weeks conceptional age to term. Those items were selected that, judging from the literature, appeared to assess developmentally, clinically, and theoretically important dimensions (Korner et al. 1987, 1991, 1999 in press).

In this study, neurobehavioral characteristics of the preterm infant using the NAPI will be described. In addition, their relations to the neurological and later neurological and psychological assessments will be analysed.

Methods

Subjects

Thirty three infants (14 boys, 19 girls) were followed. They were born in the Institute for the Care of Mother and Child in Prague(all were born prematurely (< 36 conceptional weeks), free of congenital anomalies. All were singletons. The study had an approval of the Ethical Committe of the Institute and an informed consent of the parents. Moreover, the parents were present during the examinations, and as has been shown in another study, the opportunity to see the infant during the examination was beneficial for them (Sobotková et al. 1996c). Table 1 gives a summary of the characteristics of the sample at birth, including perinatal variables.

Table 1. Characteristics of the infant sample.

Characteristics	Mean	SD	Range
Conceptional age (weeks)	32.4	2.7	25–36
Birth weight (g)	1769.4	488.4	750–2410
Apgar score at 1 min	6.4	2.0	2–10
5 min	8.2	1.2	6–10
10 min	8.6	1.0	6–10
Ventilatory support (days)	4.5	8.2	0–26
Stay at the NICU (days)	17.2	18.8	0–73
Stay at the hospital (days)	34.8	24.1	10–113
Conceptional age at assessment (weeks)	36.2	0.6	35–37

Methods Used at 36 Weeks Conceptional Age

1. Neurobehavioral Assessment of the Preterm Infant (NAPI)

All clusters defined in the NAPI manual (Korner et al. 1990) were assessed:

Scarf sign: It was originally part of the "Resistance to passive movement" cluster, but this cluster was dropped because of its low statistical cohesion. Scarf sign was retained as a single-item cluster because of its high test-retest reliability.

Motor development and vigor: This cluster consists of six items: forearm recoil, ventral suspension, prone head lifting, power of active movements, and vigor of spontaneous movements.

Popliteal angle: Also a single-item cluster, retained because of its high test-retest reliability.

Alertness and orientation cluster includes four orientation items. The responses to stimuli (inanimate and animate auditory and visual stimulation) are scored from no response to most mature response.

Irritability is evaluated according to the extent of crying.

Cry quality: The relative strength, robustness, or volume of the infant's strongest vocalization are considered.

Percent asleep ratings refer to the number of sleep states observed during the whole examination.

The examination started approximately 1 hour prior to the next feeding. We followed the instructions of the Manual and used a standard sequence of item presentation that maximized the chance of testing the various functions in appropriate states and minimized the need to intervene with some infants more than with others. Thus, similarly to the authors' experience (Korner et al. in press), our infants were mostly asleep when we began the examination, we often arose them by administering the scarf sign and the arm and leg recoil. The popliteal angle, ventral suspension, head lift and spontaneous crawling tests could then be administered in more awake states. All infants were then swaddled to calm those who became irritable. The rotation test was then administered. This was favourable for the administration of orientation items as it was found in earlier studies (Korner et al. 1966; Korner et al. 1970; Gregg et al. 1976) that the vestibular-proprioceptive stimulation entailed in moving the infants predictably produced visual alertness (Korner et al. 1999 in press).

Immediately after the examination, summary ratings were made descriptive of the infant's alertness, the extent and quality of crying, the quality of spontaneous movements, and responses to the handling and stimulation inherent in the examination.

2. Neurological Examination

The examination was a modified version of neurological examination according to the Prechtl's school (Prechtl 1964; Beintema 1968) and Vlach (Vlach et al. 1977, 1979).

Muscle tone was assessed according to the postural changes in supine, prone, and upright (during stepping movements) positions, during traction response, and vertical and ventral suspensions.

Primitive reflexes. The threshold and the intensity of palmar and plantar grasps, of rooting response, and of crawling and stepping movements were assessed.

Excitation proneness was judged according to the occurence of tremors, to the intensity of tendon reflexes, and the threshold of the Moro reflex.

Inhibition proneness. The intensity of reflex responses as well as signs of hypokinesis were considered.

Assymetries were also taken into account.

As for muscle tone and primitive reflexes, the level of the infant's performance was scored 4-point scales with 0 representing the least mature and 4 the most mature level. Complex parameters excitation proneness and inhibition proneness were scored also 4-point scales with 0 representing the lowest and 4 the highest degree of excitation or inhibition proneness. The amount of assymetries was scored 4-point scale with 0 representing absence of assymetries and 4 multiple assymetries.

Methods Used at 3 months Corrected Age

1. Neurological Examination

The examination was based on Vlach's neurological assessment (Vlach 1977). The motor development and a number of neurological items were evaluated in the supine and prone positions: muscle tone, quantity of spontaneous movements, ten-

don reflexes, primitive reflexes and responses (palmar and plantar grasps, crawling and stepping movements, Moro reflex, acoustic and optical blink reflexes) were assessed in the supine position, head and chest liftings were evaluated in the prone position. The level of the infant's performance in each item was scored 4-point scales with 0 representing less mature and 4 the most mature level. In addition, neuropathological signs like tremors, neck and back hyperextensions as well as squints and multiple assymetries were considered. Their incidence was scored 4-point scale with 0 representing absence of neuropathological signs and 4 representing very marked signs of neuropathology. In addition to the assessment of all these items (muscle tone, quantity of spontaneos movements, tendon reflexes, primitive reflexes, head and chest lifting, neuropathological signs), the total neurological status was assigned adverse summary scores 9-point scale. The scoring was based on Vlach's neurological diagnostics (Vlach 1979).

2. Psychological Examination

The Czech translation of the Bayley Scales of Infant Development – First Edition 1969 (Bayley 1983) was administered. Mental and Motor Scales were used for the assessment of mental and psychomotor development.

Results

Statistical Evaluation

For the evaluation of the relations between the NAPI assessment and neurological or psychological characteristics, unpaired t-test, correlation analysis (Spearman correlation coefficient or ANOVA were applied. For prescribed comparisons of group means, Scheffe's multiple comparison method was used. These methods were chosen because they were the most appropriate for the nature of our data.

Neurobehavioral Characteristics of 33 Preterm Infants as Assessed by the NAPI

Table 2 gives the results obtained by infants in individual functional domains (clusters). The data are presented in converted scores, derived from scores attained by infants during the examination in all items (Korner et al 1990). The converted scores from 0 to 100 indicate the level of the infant's performance with 0 representing the least mature and 100 the most mature score or they indicate the frequency of the phenomenon (how many percent asleep ratings were recorded). Thus, according to the median, mean and ranges of the values, we can judge on infants' characteristic features observed in individual domains.

Scarf sign: Elbow just beyond midline was characteristic for our sample.

Motor development and vigor: Complete and slow forearm recoil, mean extension of the infant's neck, trunk, and tighs in the ventral suspension, moving head to side and attempts to crawl in the prone position, moderate power of active movements and moderate vigor of spontaneous movements were observed.

Popliteal angle: Hip flexed to around 130° was the median value in our sample.

Alertness and orientation: The infant's alertness could be characterized by state 4 (alert inactivity), bright and shiny eyes at least half the time of the whole examination. The infant's alertness and responsivity was maintained without great

Table 2. Functional domains (clusters) – medians, means, standard deviations, and ranges of converted scores.

Characteristics NAPI clusters	Median	Mean	SD	Range
Scarf sign	66.7	59.1	14.5	33.3–100
Motor development and vigor	62.3	63.2	11.8	33.1–85
Popliteal angle	66.7	64.2	18.7	0–100
Alertness and orientation	58.6	57.4	23.6	6.3–87.7
Irritability	32.0	37.9	21.6	0–75
Cry quality	25.0	32.0	33.1	0–100
Percent asleep ratings	21.0	26.3	25.9	0–93

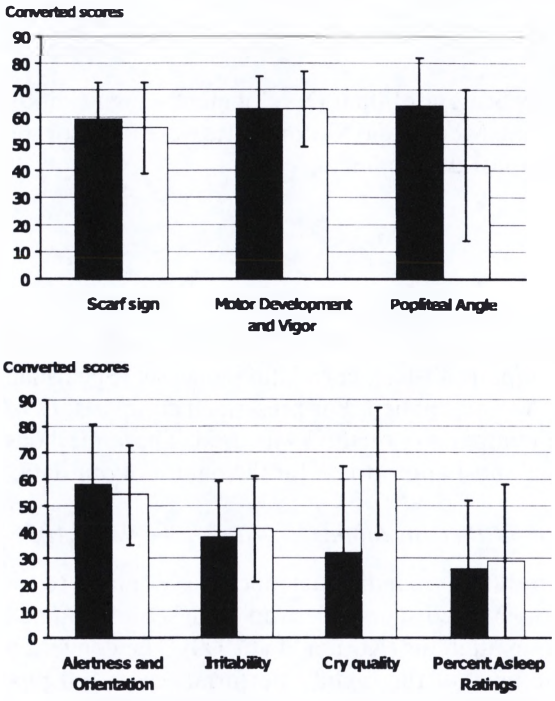

Fig. 1. ■ = Czech sample, □ = American sample.

difficulty for the examiner. As for orientation items, shifting eyes to sound and following stimulus with smooth eye movements for at least 30° were characteristic for our sample. Summary ratings revealed that no hyperalertness was observed in our sample.

Irritability: Crying was rare for our infants. Cry face was observed.

Cry quality: Weak to moderately strong strength of the infant's cry was recorded as the median value of the sample.

Precent asleep ratings: 21 percent asleep ratings during the whole examination time were ascertained as the median value. The infants slept mostly at the beginning of the examination.

Figure 1 compares the results of our sample with the results given in the Manual of the NAPI (Korner et al. 1990). The performance of Czech preterms was almost identical to that of American samples.

The Relationship of the NAPI Assessment to the Neurological Examination at 36 Weeks Conceptional Age

Table 3 shows that three NAPI clusters (Scarf sign, Motor development and vigor, Alertness and orientation) are significantly related to important items of the neurological assessment. A more mature performance of the Scarf sign was related to a more mature performance of primitive reflexes (judged by their threshold and intensity), a more mature Motor development and vigor were related to a more mature performance primitive reflexes, to a moderate intensity of reflex responses and to a more mature spontaneous motility (mostly without tremors and with the absence of hypokinesis). The Alertness and orientation cluster which consists primarily of behavioral items, was related to some neurological items too: a more mature performance in the Alertness and orientation cluster was related to a more mature preformance of primitive reflexes and to the absence of hyper- or hypotonia as judged by the postural changes in different positions.

Table 3. Relations between the NAPI clusters and neurological assessment at 36 weeks conceptional age.

NAPI clusters	Neurological asessment	Anova $p <$	Scheffe $p <$
Scarf sign	Infant's reflexes	.009	.05
Motor development and vigor	Infant's reflexes	.001	.05
	Inhibition proneness	.01	.05
	Spontaneous motility	.05	.10
Alertness and orientation	Infant's reflexes	.001	.05
	Tone	.004	.05

The Relationship of the NAPI Assessment at 36 Weeks Conceptional Age to Neurological and Psychological Evaluations at 3 Months Corrected Age

There were large individual differences in neurological findings at 3 months corrected age. Nevertheless, according to the summary score that reflects the total neurological status on 9-point scale, the findings in majority of infants corresponded to their corrected age. The mean score (SD) was 3.38 (2.00), and only 3 infants had their score > 6.

As for psychological findings as judged by the Mental and Motor Bayley Scales, the values of Mental Development Index of all infants were normal (mean MDI = 104.4, SD = 8.8, minimum = 91, maximum = 127). The mean value of the Psychomotor Developmental Index fell also into the normal limits (= 98.6 with SD = 12.6), but some values were lower than would correspond to the corrected age (minimum = 67).

We can see from Table 4 that three NAPI clusters are related to the neurological and psychological assessments at three months corrected age. A more

mature performance in Motor development and vigor at 36 weeks is related to the more mature performance in motor development, as judged by Bayley's Psychomotor Developmental Index at 3 months, and to higher degree of maturity of two items of neurological assessment (prone head raising and Moro reflex) at 3 months corrected age. Higher irritability during the NAPI assessment at 36 weeks conceptional age, seems to be related to a lower Mental Developmental Index (Bayley) at 3 months (rho = $-.35$, $P < .06$). It is interesting that the summary assessment of neurological status at 3 months (Total score of neurological assessment) correlates significantly ($P < .05$) with the Alertness and orientation cluster.

Table 4. Relations between the NAPI at 36 weeks conceptional age and neurological and psychological assessments at 3 months corrected age.

NAPI clusters	Assessment at 3 month	p <	Methods applied
Motor developmental and vigor	Psychomotor developmental index (Bayley PDI)	.04	Spearman: Rho = .36
	Prone head lifting – neurological assessment	.04	t-test: t = 2.28
	Moro reflex – neurological assessment	.01	t-test: t = 2.54
Irritability	Mental Developmental Index (Bayley MDI)	.06	Spearman: Rho = .35
Alertness a. orientation	Total score of neurological assessment	.05	ANOVA, S-method

Discussion

The behavioral state of the infants in the course of the examination by the NAPI was very favourable: the infants slept mostly only at the beginning of the examination, the infant's alertness and responsivity were maintained without great difficulty for the examiner, crying was rare. There may be a number of different reasons for the infant's favourable state during the examination. One of them may be due to the fact that the NAPI does not include stressfull manoeuvres (e.g., pull-to-sit) or aversive tests (e.g., the pin prick and the Moro reflex).

The relatively high responsivity to visual and auditory stimulation observed during the examination may be due to the inclusion of only four orientation items: it was found in a pilot study (Korner et al. 1983) that preterm infants tended to fatigue and became unresponsive when a higher number of orientation items was administered. The swaddling of the infant during the administration of orienation items might also be favourable for eliciting the infant's best performance as has been shown in the literature: the quieting of the preterm infant by swaddling resulted in increased preferential looking (Gardner et al. 1982).

The other reason for the relatively high responsivity observed during orientation items, may be caused also by the fact that the orientation items followed the rotation item: the literature shows that the vestibular-proprioceptive stimula-

tion entailed in rotation is very effective in producing visual alertness in neonates (Korner et al. 1966; Gregg et al. 1976; Korner et al. 1983).

Neuromotor items included in the Scarf sign and Motor development and vigor clusters were significantly related to the items of neurological assessment made at the same age. Moreover, Alertness and orientation cluster consisting of behavioral items was significantly related to neurological items (Infant's reflexes, Tone) too. This indicates that the behavioral and neuromotor phenomena are interrelated at this age, and that the NAPI and neurological assessments complement each other.

Although the primary goal of the NAPI is to assess the maturity of an infant current functioning and not to predict future developmental progress, the analysis of the relationships between the NAPI assessment at 36 weeks conceptional age and neurological and psychological status at 3 months corrected age, revealed some predictive value of the NAPI: three NAPI functional domains (Motor development and vigor, Alertness and orientation, Irritability) were related to the neurological and psychological assessments at 3 months. The significant correlation between Alertness and orientation cluster and the Total score of neurological assessment may be viewed as a further indication of the close interrelation between the behavioral and neuromotor phenomena at an early age. The correlation coefficient between the Irritability at 36 weeks conceptional age and the Mental Developmental Index at 3 months corrected age only approaches the level of statistical significance. Nevertheless, the negative correlation between irritability in the earliest phases of development and further developmental progress might be rationally interpreted in terms of low incidence of a quiet waking state that results in a low stimulation supply.

The high agreement of the results gained on Czech infants with the data on American infants (Korner et al. 1990) is interesting. It may indicate that the biological development may overshadow differences in psycho-social environment in the earliest phases of development in preterm infants. This conclusion fits in with our previous data on sleep states in preterm infants (Dittrichová et al. 1994).

High responsivity of the preterm infant and its favourable state during the examination, high agreement of the NAPI assessment with the results of neurological examination, the relationship of the NAPI assessment at 36 conceptional age to neurological and psychological evaluations at 3 months corrected age, the close similarity between the results of Czech and American babies, lead us to the conclusion that the NAPI assessment is a valuable method for assessing the early phases of neurobehavioral development in preterm infants. Thus, data on current neurobehavioral functioning revealed by the NAPI may serve as an appropriate basis for the establishment of an individual infant-oriented intervention program. In addition, the administration of the NAPI in the presence of the parents, enhances parental awareness and has potential educational benefits as has been shown in the literature (Constantinou et al. 1993; Sobotková et al. 1996c).

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