Time takes time to pass; considerations about neuro-motor development and early intervention

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Chapter 3:

SPECIFIC POSTURAL SUPPORT PROMOTES VARIATION IN MOTOR BEHAVIOUR OF INFANTS WITH MINOR NEUROLOGICAL DYSFUNCTION[c]

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Chapter 3:

SPECIFIC POSTURAL SUPPORT PROMOTES VARIATION IN MOTOR BEHAVIOUR OF INFANTS WITH MINOR NEUROLOGICAL DYSFUNCTION

Abstract

The present study aims at evaluating the effect of specific postural support on motor behaviour of infants with and without minor neurological dysfunction (MND). The following questions were addressed: Does application of supportive pillows affect the time during which the infant exhibits general movements (GMs) or specific movements? We defined specific movements as movements of specific parts of the body which occur in a specific, recognizable way. Does application of pillows improve the quality of GMs or the repertoire of specific movements? Is a pillow effect affected by neurological condition?

Forty healthy full-term infants aged 1-5 months participated in the study. Twenty were neurologically normal and twenty had MND. Spontaneous motor behaviour in supine position was video-recorded for 180 seconds in four conditions applied in random order: support by a pillow in the shoulder region, the pelvic region, shoulder and pelvic region or no pillow support. Two independent assessors evaluated the quality of GMs. The other movement parameters were assessed with a computer program. Duration of movements was determined and a variation index, consisting of the number of different specific movements in a condition, was calculated. The presence of pillows did not affect the time spent with GMs or specific movements or GM-quality. In neurologically normal infants the shoulder pillow with or without pelvic pillow induced an increase in the variation index ($p<0.01$), whereas in the infants with MND all pillow conditions resulted in a substantial increase of the movement repertoire ($p<0.001$). Thus, specific postural support promotes variation in motor behaviour of young infants. This is particularly true for infants with MND.

Introduction

Paediatric physical therapists often apply specific postural support in order to improve motor performance of children with developmental disorders (Howle 2002). Interestingly, this practice is supported by limited evidence on effectiveness and efficacy only (Roxborough 1995, Washington 2002).

The effect of postural support on motor behaviour during infancy has been addressed in a few studies of preterm neonates and some of infants aged 5 to 18 months. Provasi and Lequien (1993) reported that placement of preterm neonates in a reclining infant seat during parts of the day resulted in a reduction of cloni and startles. Monterosso et al. (2003), who studied the effect of postural support in preterm infants when nursed in prone, demonstrated that a postural support role improved shoulder posture at term age and the combination of a postural support role and a postural support nappy gave a better hip posture. Finally, the study of Vaivre-Douret and colleagues (2004) indicated that variable placement of the preterm infant in supine, prone and side position resulted in a better neuromotor condition at term age than standard placement in prone. Thus, the studies on the effect of position and postural support prior to term age indicate that postural support might have a beneficial effect on the infant's motor behaviour. The studies carried out in older infants show a similar trend. The studies of Rochat and Goubet (1995) and Hopkins and Rönnqvist (2002), which dealt with typically developing 'non-sitting' infants aged 5 to 6 months, indicated that support in the pelvic region of sitting infants facilitated upper extremity function. However, the study of Washington et al. (2002) on four seated infants with developmental motor disorders aged 9 to 18 months, indicated that specific postural support did improve postural alignment, but had no significant effect on reaching and grasping behaviour. Information on postural support and motor behaviour in infants during the first months after term age is limited to the description of Grenier (1981) that provision of firm support of the neck and trunk in seated neonates may enhance the generation of 'pre-reaching' movements.

The aim of the present, explorative study is to evaluate the effect of specific postural support on motor behaviour of infants aged 1 to 5 months. We focussed on this age period as it is an age period with a major transition in neural functions (Prechtl 1984). It includes the last phase of general movements (GMs), i.e., the phase of fidgety GMs which are present between 2 and 4 months post-term (Touwen 1976, Hadders-Algra 2004). It also includes the onset of goal directed motility, which emerges around the age of 3 months (Touwen 1976). In addition, 3 month is an age of transition in postural development: after the transition spontaneous motor behaviour and reaching movements are more tightly coupled to postural behaviour than prior to the transition (Van der Fits et al 1999, Hedberg et al 2005). We studied the infants in supine position as this is a position in which young infants spent major part of the day. The specific postural support consisted of the application of a horseshoe formed shoulder pillow, a pelvic pillow or both pillows. Besides typically developing infants, infants with minor neurological dysfunction were studied as we hypothesized that in particular infants with dysfunction would benefit from postural support. The following questions were addressed: 1. Does the application of supportive pillows affect the time during which the infant exhibits GMs or specific movements? We defined specific movements as movements of specific parts of the body which occur in a specific, recognizable way. 2) Does the application of supportive pillows improve the quality of GMs or 3) the repertoire of specific movements generated by the infant? We also investigated whether a potential pillow effect was affected by the infant's neurological condition. The second and third question reflect that we were not only interested in a quantitative effect of pillow support but also in a qualitative effect. The quality of GMs and the repertoire of specific movements are both parameters of variation indicator in motor behaviour and as such related to a favourable neuromotor development (Hadders-Algra 2000).

Method

Participants

Forty healthy full-term infants (16 boys, 24 girls) participated in the study. They were born without pre- and perinatal complications and recruited at the obstetrical department of the University Medical Centre Groningen (UMCG) between April and July 2001. We deliberately recruited at this university hospital as we knew from previous studies that the prevalence of MND in healthy full-term infants born in a university hospital is considerably higher than that in the general Dutch population where a large proportion of infants is born at home[17]. The infants' gestational age at birth varied from 38 to 42 weeks postmenstrual age (median value: 39 week); birth weight from 2800 to 4260 grams (mean: 3562 g; SD: 448 g). Motor behaviour was recorded at ages of 1, 2, 3, 4 or 5 months. The distribution of the infants across ages is presented in Table I. The parents of the infants gave informed consent and the procedures were approved by the ethics committee of the UMCG.

Table I: Distribution of infants across ages and neurological condition

Age in months	**Total** **N = 40**	**Neurologically normal** **n = 20**	**MND** **n = 20**
1	6	2	4
2	5	4	1
3	15	7	8
4	7	4	3
5	7	3	4

MND = minor neurological dysfunction indicating the presence of mild neurological abnormalities and/or mildly abnormal GMs

Procedure

The session started with a video-recording of spontaneous motility in various supine conditions. During the recording the infants were dressed in diaper and underwear only. The infants were lying on a thin, flat mattress with or without support of specific pillows which could be easily moulded and adapted to the size of the infant. Motor behaviour was recorded in four conditions, which were randomly applied. The conditions were: 1) the standard condition in which the infant was lying on the mattress without pillow support, 2) the shoulder pillow condition in which the infant's head, neck, shoulders and arms were supported by a soft, thin and flexible horseshoe formed pillow, 3) the pelvic pillow condition in which a soft, thin and flexible rectangular pillow was placed below the buttocks in such a way that it induced a slight passive pelvic anteflexion, 4) the combined pillow condition in which the infant was supported by both the shoulder and pelvic pillow (Fig. 1). The infant's motor behaviour was recorded for approximately 5 minutes in each condition. Care was taken to record motility in an active, awake, non-crying state. If an infant started to cry, recording was interrupted. Recording was restarted when the infant had regained the appropriate behavioural state. If the infant turned into prone position – which occasionally happened in the oldest infants, the examiner returned the infant into supine. Due to the interruptions some conditions were recorded less than 5 minutes (300 seconds); therefore we decided to select of every condition 180 seconds for analysis. No toys were offered to the infant and parents and examiner refrained from interaction with the infant. All infants were naïve to the pillow conditions

After the video-session a standardized neurological examination according to Prechtl (1977) with age-specific adaptations of the norms according to Touwen (1976) was carried out (assessors AHdGH or MHA). The neurological findings were summarized as normal, mildly abnormal or definitely abnormal (Jurgen-van der Zee 1979). Definitely abnormal denoted the presence of a full-blown neurological syndrome, such a hemisyndrome, a hyperexcitability syndrome or a clear hypo- or hypertonia.

Mildly abnormal indicated the presence of only a few signs of the full syndrome.

Figure 1

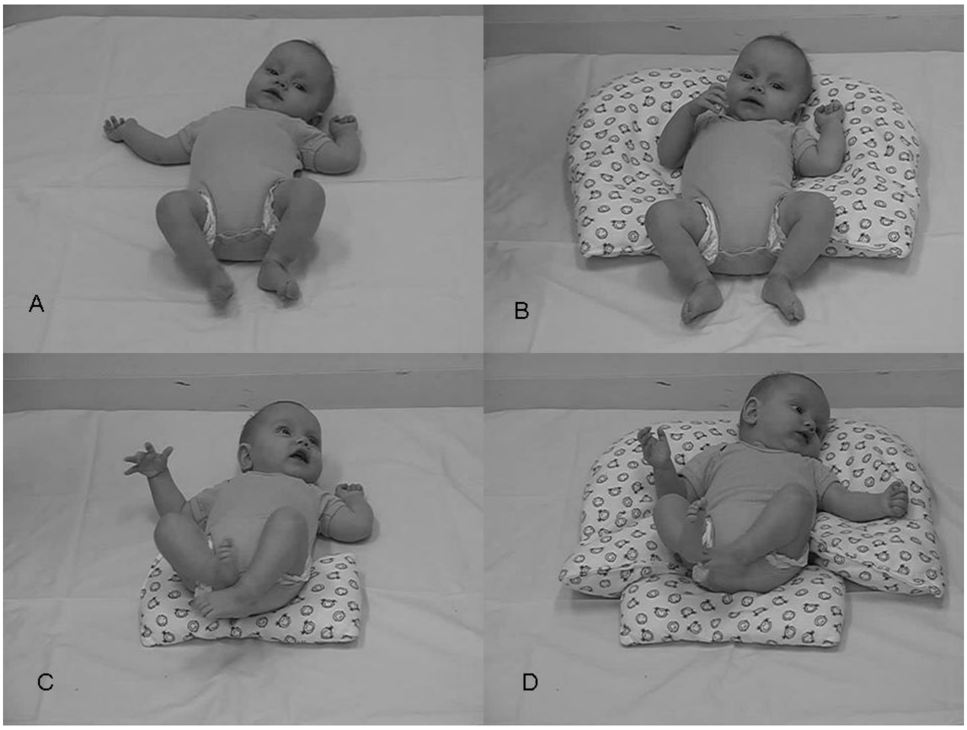

Figure 1

Infant of 4 months in the four different conditions. A) Standard condition without pillow, B) shoulder pillow condition, C) pelvic pillow condition, D) combined pillow condition. Figure published with permission of the infant's caregivers.

Data analysis

Three minutes (180 seconds) of video-recording of spontaneous motility in an active, awake, non-crying behavioural state of each condition were analysed in two ways. The first assessment consisted of an evaluation of the quality of GMs. Four GMs qualities were distinguished: normal-optimal GMs, normal-suboptimal GMs, mildly abnormal GMs and definitely abnormal GMs (Hadders-Algra 2004). In order to reduce bias of the assessor on preconceived ideas on the effect of pillow support, four condition specific tapes were created on which 3 minutes of spontaneous behaviour of the 40 infants was presented in a random order. The 4 times 40 video-fragments were assessed by two observers (VBdGP and CHBH). Agreement was high: Cohen's kappa was 0.91. In case of disagreement a third observer (MHA) was consulted and findings were discussed until consensus was reached.

The second assessment consisted of a detailed quantitative assessment of motor behaviour. This assessment was carried out with help of `The Observer 5.0' (Noldus, Wageningen, the Netherlands), a computer application especially designed for behavioural observation (assessors: VBdGP and LV). The Noldus Observer software is a tool for collecting and analysing observational data. It allows the construction of a framework of behaviours, data collection according to the framework, on the basis of which a descriptive and quantitative analysis of the data can be performed. Behaviour can be analysed on a frame by frame basis with a temporal resolution of up to 0.04 seconds. The program allows – amongst others - for the quantification of duration, frequency and serial order of defined behaviour. In the present study we focussed on the occurrence of GMs and specific movements. Specific movements were defined as movements of specific parts of the body which occur in a specific, recognizable way. Selection of these movements was largely based on Hadders-Algra et al (1992) and Hopkins and Prechtl (1984). For definitions of the various specific movements see Table II. Specific movements were only scored if they lasted ≥ 0.5 second. A GM was scored when various parts of the body moved arbitrarily, i.e., the movements could not be categorized into one of the predefined specific movements. The onset and end of each movement (first and final frame of the movement) were scored. Interobserver agreement on the classification of the various movements of a random sample of 20 of the 40 video's was high: Cohen's kappa was 0.98. In case of disagreement findings were discussed until consensus was reached.

Data processing

The first movement parameters derived from the Observer data were the time spent on various movements, i.e., time spent on GMs and on specific movements of the arms and specific movements of the legs. The second parameter was the frequency of occurrence of various movements. The frequency represents the total number of movements seen within the video clip interval of 180 seconds, counting the same movements as a separate value each time. Third, a variation index was calculated. The variation index refers to how many different movements among the list in Table II were observed in a specific condition. Due to the fact that some of the twenty movements listed in Table II could be performed with a right limb, a left limb or both limbs, the maximum score of the variation index was 52.

Table II: Definition of specific movements in the Observer analysis.

Body part	Movement	Definition
Trunk	rolls to left side	rolls to left side up to 135°
	rolls to right side	rolls to right side up to 135°
	turns into prone over left side	turns over the left side into prone or almost into prone, i.e. > 135°
	turns into prone over right side	turns over the right side into prone or almost into prone, i.e. > 135°
Arm	looking at hand or hands	infant visually fixates one or two hands
	playing with hands	hands meet in midline, touch or clasp

		each other in an explorative way
	'crucifix posture' of the arms	posture in which both arms lie abducted and extended on support surface
	sucking on hand or hands	sucking on one or two hands
	hand or hands move near mouth	one or two hands is/are moved towards or in the neighbourhood of the mouth
	hand or hands touch face	one or two hands touch the face, with exception of the mouth
	hand or hands touch the head	one or two hands touch non-facial parts of the head
	hand or hands touch trunk	one or two hands touch the trunk
	hand or hands touch leg	one or two hands touch one or both upper legs
	hand or hands touch knee	one or two hands touch one or both knees
	hand or hands touch feet	one or two hands touch foot or feet
Leg	looking at foot or feet	infant visually fixates foot or feet
	pelvic tilt	anteflexion of the pelvis resulting in an upward movement of the knees
	Arching	pushes bottom up with legs
	Foot-foot contact	feet touch each other
	Foot touches leg	foot touches contralateral leg with exception of contralateral foot

Statistics

Statistical analyses were performed using the computer package SPSS (version 11.5). Non-parametric statistics were used as none of the movement parameters was normally distributed. The age-dependency of the occurrence of specific movements was analysed with help of the Mann-Whitney U Test. The analysis focussed on the effect of application of one or two pillows in comparison to the standard situation. This means that we performed for each parameter three comparisons with help of the Wilcoxon test. In order to reduce the threshold for significance a Bonferroni method was used because of the problem of multiple testing, which means that p-values of < 0.0167 (i.e. 0.05/3) were considered as statistically significant.

Results

Neurological condition

Fifteen infants showed mild abnormalities at the neurological examination, the remaining 25 had a normal neurological condition. The mild abnormalities varied from a mild hypotonia (n=2), a mild hypertonia (n=2), a mild hyperexcitability (n=4), a mild hemisyndrome (n=4) to a mild visuo-motor deficit (n=3). GM-assessment in the standard condition revealed that 5 infants had mildly abnormal GMs, 16 normal-suboptimal GMs and 8 normal-optimal GMs. Eleven infants, four aged 4 months and seven aged 5 months, did no longer show GMs when put into supine. For the analysis of the effect of one or two pillows two groups were formed: the neurologically normal group, which consisted of infants with a normal neurological condition and normal GMs (n=20) and a group of infants with minor neurological dysfunction (MND), which consisted of infants who had a mildly abnormal neurological condition and/or mildly abnormal GMs (n=20; Table I). Only three infants showed the combination of a mildly abnormal neurological condition and mildly abnormal GMs, the other 17 had mild dysfunction in only one of the two assessments. Gestational age at birth, birth weight, gender and age at assessment of the neurologically normal infants and the infants with MND did not show a statistically significant difference.

Occurrence of specific movements

Before addressing the effect of pillow support on motor behaviour we assessed the effect of age on the frequency of specific movements in the standard condition. The frequency of specific movements increased with increasing age, in particular from 3 months onwards. The increase of specific movements at 3 months of age was present both in the group of neurologically normal infants (Mann-Whitney U: 1-2 months versus 3-5 months: $p < 0.001$) and in the group of infants with MND (Mann-Whitney U: 1-2 months versus 3-5 months: $p=0.001$; Fig 2).

Effect of pillow support on motor behaviour

The presence of one or two pillows did not affect the time spent on GMs or on specific movements (Table III) nor did it affect the quality of GMs (Table IV). However, the frequency of occurrence of specific movements and the variation index was affected by pillow condition (Fig. 3). In the neurologically normal group the presence of pillows did not affect the frequency of occurrence of specific movements, but it affected the variation index to some extent. In the presence of a pelvic pillow with or without a shoulder pillow the variation index was higher than in the standard

condition without pillows ($p < 0.01$). In the infants with MND the presence of supporting pillows affected both the frequency of specific movements and the variation index. In the presence of a shoulder pillow or a pelvic pillow infants with MND produced more specific movements than in the standard condition ($p < 0.01$). In infants with MND all three conditions with pillow support were associated with a significant increase of the variation index ($p < 0.001$).

Figure 2

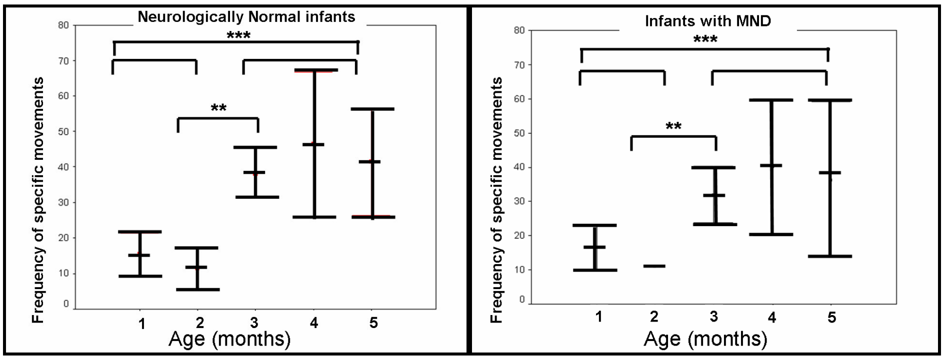

Figure 2

Age dependency of frequency of occurrence of specific movements in the standard condition. The vertical lines indicate the range and the horizontal lines the median value. Mann-Whitney U Test *** p < 0.001, ** p = 0.004

Table IV Quality of GMs in the various condition

	Standard-Condition n (%)	Shoulder-Condition N (%)	Pelvic-Condition n (%)	Combined-Condition n (%)
Normal-optimal GMs	8 (20)	7 (18)	6 (16)	6 (16)
Normal-suboptimal GMs	16 (40)	16 (40)	19 (46)	20 (48)
Mildly abnormal GMs	5 (12)	4 (10)	6 (14)	7 (16)
No GMs	11 (28)	13 (32)	9 (24)	7 (20)

Figure 3

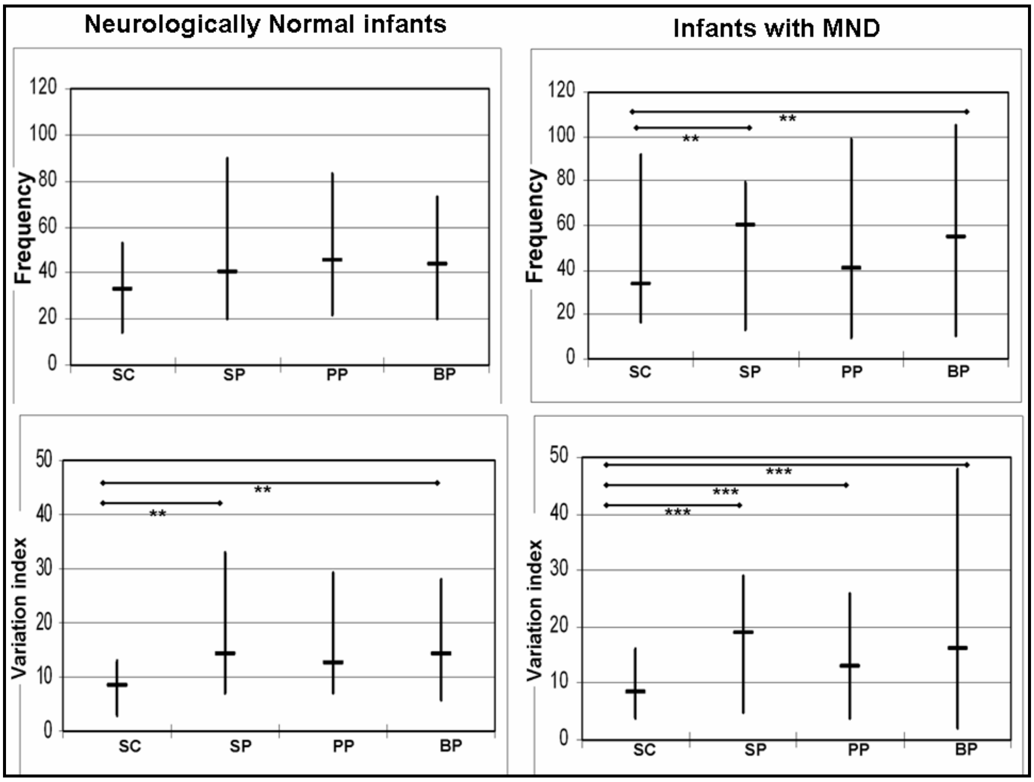

Figure 3

Effect of pillow condition on the frequencies of occurrence of specific movements and variation index in neurologically normal infants (left hand panels) and infants with MND (right hand panels). The vertical lines indicate the range and the horizontal lines the median value. SC = standard condition, SP = should pillow condition, PP = pelvic pillow condition, BP = both / combined pillow condition. Wilcoxon: ** $p < 0.01$, *** $p < 0.001$.
Friedman statistics in neurologically normal infants: frequency of occurrence of movements, $p = 0.12$; variation index, $p = 0.004$; in infants with MND: frequency of occurrence of movements, $p = 0.02$; variation index, $p < 0.0001$.

Table III Time spent on GMs and specific movements in the various conditions in seconds.

	Standard condition		Shoulder pillow condition		Pelvic pillow condition		Combined pillow condition	
Neurological Condition	Normal	MND	Normal	MND	Normal	MND	Normal	MND
GMs: median range	 49.1 0 - 153.9	 58.1 0 - 128.8	 40.4 1.2 - 175.7	 43.2 1.0 - 155.5	 54.5 4.8 - 155	 53.7 0 - 118.4	 50.8 0 - 143.5	 48.9 2.0 - 139.2
Spec mov arms: median range	 130.9 26.6 – 180	 121.9 52 – 180	 139.7 4.3 - 178.8	 136.8 24.5 - 179	 125.5 24.9 – 175.2	 125.9 61.7 – 180	 129.2 36.5 - 180	 131.1 40.8 – 178
Spec mov legs: median range	 89.4 16.4 - 158.9	 47 4.3 - 148.6	 50.9 0 - 164.9	 43.4 3.7 - 154.3	 72.7 0 - 167.9	 59.6 2.9 - 173.3	 34.8 0 – 169.8	 42.6 13 – 165
Spec mov total: median range	 94.5 9.4 - 180	 95.1 0 - 180	 96.5 2.2 - 175.4	 92.2 17.7 - 175.6	 104.7 10.6 - 165.2	 107.7 0 - 180	 88.5 3.4 - 180	 97.4 13.7 – 173.8

GMs, general movements; MND, minor neurological dysfunction; spec mov, specific movements

Discussion

Our study indicated that specific postural support in supine position results in an increase in the frequency and the repertoire of specific movements of infants with minor neurological dysfunction. Neurologically normal young infants who already show variable motor behaviour seem to benefit less from specific postural support. Our findings fit to the literature data summarized in the introduction.

Weak points of the present study are that it evaluated the effect of pillow support in a relatively small group of infants in whom neurological dysfunction was restricted to minor dysfunction. This means that the findings of the present study cannot be extrapolated to the general population of infants with MND nor to infants with a definitely abnormal neurological condition. The strength of the study lies in the unbiased, blind assessment of GM-quality by two independent assessors and the objective quantification of motor behaviour by means of the computer program Observer.

Specific pillow support did not affect the quality of GMs. This finding underscores the notion that GMs are endogenously generated motor patterns, which are relatively insensitive to direct environmental influences (Prechtl 2001, Hadders-Algra 2004). Specific pillow support however, did affect the size of the repertoire of specific movements, in particular in infants with MND. The support provided by the pillows appeared to facilitate spontaneous exploration of specific movements, which in turn seems to be associated with favourable motor development (Hadders-Algra 2000). The reverse might also be true, i.e., that a restriction of the possibilities of spontaneous exploration of motor behaviour may have an adverse effect on motor development. Support for this idea has recently been provided by

Bartlett and Kneale Fanning (2003) who reported a negative correlation between the duration of daily carrying and sitting abilities in 8-months-old high risk preterm infants.

The pillows affected motor behaviour of neurologically normal infants less. The limited pillow effect in this group probably is a ceiling effect: if you already show variable motor behaviour it is difficult to become more variable. However, the recent study of Majnemer and Barr (2005) which reported a positive association between exposure to 'tummy time' while awake and level of gross motor development in healthy infants, suggests that also typically developing infants may benefit from specific positioning.

The finding that specific pillow support did not affect GM quality but did affect the frequency and repertoire of specific movements, suggests that specific pillow support may facilitate motor behaviour first after the major neural transformation occurring at the age of 3 months (Prechtl 1984). The age of 3 months is the age at which specific movements become a prominent part of motor behaviour (Prechtl 1984, Fig. 2). It is the age of transition in postural development (Hadders-Algra 2005) after which spontaneous motor behaviour and reaching movements become more tightly coupled to postural behaviour (Van der Fits et al 1999, Hedberg et al 2005). This may explain why infants with MND, who in general have minor dysfunctions in postural control (Hadders-Algra 2005), may benefit from external postural support during the early developmental phases of goal directed motor behaviour.

The present study indicates that pillow-support in supine position enhances variation in concurrent motor behaviour in infants with MND. Whether the effect of pillow support is also present in infants with clear neurological dysfunction and – even more important – whether daily application of pillow support would result in a more favourable neuromotor development, are pressing questions for future research.

Concluding remarks

The present study indicates that specific postural support promotes variation in motor behaviour of young infants. This is particularly true for variation in specific movements - which become a prominent part of the motor repertoire from 3 months onwards - in infants with MND. Further research is needed to evaluate whether the effect of specific pillow support also occurs in infants with clear cut neurological dysfunction.

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