FETAL MOVEMENTS IN MID-PREGNANCY AND THEIR RELATIONSHIP TO NEONATAL COMPETENCY

A PILOT TRIAL

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SUMMARY

The aim of the study was to investigate the relationship between fetal movement and neonatal behaviour, as well as to compare the fetal movement patterns and neonatal competencies of black and white infants.

The sample for the pilot trial consisted of 12 mothers and their infants, selected at between 10 and 12 weeks of gestational age. The black sample and part of the white sample was drawn from the low-risk population attending the booking clinic of St Monica's Hospital; the rest of the white mothers were drawn from the private sector. Nine mothers satisfied the criteria throughout the trial. Two had to be excluded when their pregnancies were terminated and a third was excluded due to epilepsy.

Fetal movement was recorded by ultrasound scanning at 20/52 gestational age, recorded on videotape. All infants were born at full term by normal vertex delivery. The Brazelton neonatal behavioural assessment scale (BNBAS) was performed between 12 and 36 hours post-birth. This assessment was also videotaped.

Test-retest reliability for counting and classifying fetal movements was established at 99,45 (SF=1.05). Sequential and isolated movements predominated and the proportion of sequential and isolated movements was related to the total number of fetal movements. Higher FM scores were also related to more optimal scores on the BNBAS in the neonatal period. The black infants tended to show more mature patterns of fetal movement that the white infants. The black infants also scored better on the BNBAS in relation to optimal postural tone, motor maturity and good orientation/alertness. The number of subjects in the pilot trial was too small for statistical analysis, but the results justify continuation of the main trial.

Introduction

Studies of fetal movement patterns have proliferated in the last decade, the most authoritative of these studies having been carried out in the Netherlands.[1,2,3]

Studies to date can be divided into three categories:

- quantitative approaches with the aim of monitoring fetal viability
- qualitative studies with the aim of classifying fetal movement patterns and analysing their developmental course
- studies of fetal biorhythms and behavioural states.

So far there are no published cross-cultural studies of fetal movement.

De Vries, Visser and Prechtl (1984), classify fetal movements into 16 categories, ranging from primitive movements such as startles and jumps, through locomotive and propulsive movements to isolated limb movements.[1] Their classification of movements correlates well with movements described in earlier studies[4,5,6], although the age of onset was often found to be earlier. This could be due to the longer observation time in the latest study, coupled with the use of video-recordings which allowed review of movements.

Several authors[3,7,8,9] describe a specific sequence of emergence of increasingly selective and complex patterns of movement, most movements remaining consistent in pattern once established. Fetal orientation has also been reported to show developmental trends[1,3]. Changes in position increase in number from 1–15 weeks, thereafter decreasing in response to the confines which the uterus imposes on the growing fetus[1].

Although diurnal variations in fetal movement occur from about 20 weeks' gestation[10], true behavioural states are not found until after 36 weeks[11,12]. Pillai and James (1990) found that behavioural states 1F and 2F in the full term fetus were comparable to states S1 and S2 in the newborn, but did not find any other correlations[13].

Prechtl (1985) considers that fetal movement patterns are closely related to patterns seen in the neonatal period and in early development[7]. The complexity of patterns already seen at 20 weeks' gestation, when the morphological development of the nervous system is very incomplete, is explained by Touwen (1989)[14]. He postulates that the generation of motor patterns is a primary function of the central nervous system even at a very low stage of development, and that this is utilised post-natally when patterns developed in utero become linked to specific afferent information in the acquisition of motor control and adaptive functions.

Only one study has been traced which compared fetal movement to motor activity in the neonatal period[15]. In this study 51 patients hospitalised for complications of pregnancy recorded fetal movements for one hour, twice daily. It is stated that no factors known to affect fetal movement were present in any of the subjects. All infants were born healthy and no correlation was found between mean fetal movement scores and neonatal performance on a partial (sic) Brazelton neonatal behavioural assessment (BNBAS). There were, however, several design faults inherent in this study.

A further study[16] showed an association between the pre- natal rate of habituation to vibrotactile stimulation and autonomic stability measured with the BNBAS, the fast habituators scoring lower on autonomic stability post-birth.

If the number and pattern of fetal movements can be related to neonatal competency and early motor development, improved knowledge of fetal movement will provide a better basis for identifying infants at risk for developmental disability.

At the same time this study will contribute towards formulating a standardised classification of fetal movements, the need for which has been identified by de Vries *et al* (1982) and Cintas (1987)[2,17].

When evaluating infants for developmental delay or signs of cerebral motor disturbance a sound knowledge of the developmental norms for the population concerned is essential. Conflicting evidence for and against advanced development in black African infants has been published for over 50 years. Early reports purporting to demonstrate precocity[18,19,20,21] have been criticised for defects in design and measurement, and in particular for the fact that comparisons have been made with test norms established in other countries instead of by comparing samples within an African country[22,23].

A recent study of Western Cape infants[24,25] involved 681 black and 741 white infants, and found South African urban infants to be in advance of American infants when tested on the Denver Developmental Screening Test (DDST)[26]. Some significant differences in motor development were also found between the black infants and the white infants, particularly during the first year of life. Differences in motor abilities appeared to be partially due to child handling practices, supporting the views of some earlier researchers[27,28,29,30]. The differences in handling practices were, however, insufficient to account for the advanced motor behaviour of the black infants early in the first year of life, supporting the views of other workers[31,32,33] that the genetic factors may play a role. Should this be so, differences in fetal movement and neonatal behaviour may be expected.

The aim of this study is therefore two-fold:

- to investigate the relationship between fetal movement and neonatal behaviour
- to compare the fetal movement patterns and neonatal competencies of black and white infants.

Subjects and method

The sample for the pilot trial consisted of 12 mothers and their infants, selected at between 10 and 12 weeks of gestational age.

Initial exclusions included mothers who were aged less than 18 years or more than 37 years at the time of conception, those with a history of previous caesarian section, perinatal death or pre-eclampsia, known hereditary disease, maternal malnourishment, acknowledge drinkers or smokers, unmarried mothers and those living outside the greater Cape Town area.

The black sample and part of the white sample was drawn from the low-risk population attending the booking clinic at St Monica's Hospital; the rest of the white mothers were drawn from the private sector. In both groups the first five consecutive mothers satisfying the criteria were accepted. Of the initial 10 mothers, two (#1 and #10) had to be excluded when their pregnancies had to be terminated; a further two mothers were thus taken into the sample. One other mother (#6) had to be excluded due to epilepsy, leaving four black and five white mothers in the sample.

Fetal movement studies consisted of sonar scanning at 20/52 gestational age, recorded on videotape. The scanner used was an Aloka Echo Camera Model SSD-650 with convex sector scanner operating at 3,5MHz across 60 degrees. Measurements of biparietal diameter, femur length and abdominal circumference were taken in order to confirm the gestational age. With the mother lying supine, the transducer was then positioned parallel to the long axis of the vertebral column of the fetus and was held stationary for the duration of the 30 minute recording, unless the fetus changed its orientation in the uterus (in which case the transducer was turned until the fetus was again viewed in sagittal or parasagittal section). All recordings were made between 16h00 and 18h00.

Three videotape recordings were made on other fetuses at 20 weeks, under the same conditions, in order to establish test-retest reliability for number and classification of fetal movements. Reliability was established at 99,45 (SE=1,05) using a Pearson correlation coefficient.

It was originally intended to compare the FHR during periods of gentle and more forceful movement, but with the apparatus available it was impossible to record FHR accurately during forceful movement. During gentle movement the mean FHR was 125.

The Brazelton neonatal behavioural assessment (BNBAS)34 was performed between 12 and 36 hours post-birth, in the neonatal nursery at St Monica's Hospital or in a private ward in the case of infants born elsewhere. This assessment was also video recorded.

Results

Characteristics of the mothers

The mean age of the mothers at time of conception was 25 years 6 months, with a range of 20-31. Fifty percent of the mothers were primigravidas. In all cases except one the foetal measurements corresponded with the gestational age calculated from the last menstrual period; the mean gestational age at the time of the sonar studies was 20,2, with a range of 19,4-20,6.

The average educational level was standard 10 (range 7-4 year degree) and the fathers' occupations all fell

into the so-called blue-or White-collar categories. All mothers were non-smokers.

Characteristics of the infants

All infants were born at term by normal vertex delivery. Duration of labour ranged from 6hr 10 min to 11hr 35min.

There were no perinatal complications and all infants had a five minute Apgar score of 9. One infant had slight evidence of amniotic bands around one ankle, with no limitation of movement.

Fetal movement studies

Since studies reported in the literature had found quiet periods during recordings, the period of each recording was divided into 3-minute windows and, in addition to number and type of movement, the strength of movement was noted as being gentle, forceful or forceful with change of position. However, no empty windows were found in any of the recordings, most windows containing movements of different strength. Type 3 movements (forceful with change of position) were also not limited to windows in which a large number of movements were recorded. The final analysis was therefore carried out over the full 30 minute period.

The average total number of fetal movements over the thirty minute period was 237,88, ranging from 160 to 316.

TABLE I: CLASSIFICATION OF FETAL MOVEMENT TYPE AT 20 WEEK GESTATIONAL AGE

FM TYPE	FETUSES								
	2	3	4	5	7	8	9	11	12
Startles	4	4	-	-	1	-	4	-	1
Wriggles	27	45	40	30	18	29	30	35	27
Twitches	17	6	7	30	44	37	19	31	16
Clonus	-	2	-	5	3	2	-	-	-
Jumping	17	35	39	14	20	18	12	10	14
Creeping	7	5	11	2	14	4	3	18	9
Stretching	6	4	3	-	-	4	5	-	-
Arm movements	24	29	28	16	22	42	50	4	28
Finger movements	4	2	7	1	3	5	3	-	-
Hand-to-face	4	-	8	-	2	7	2	-	8
Leg Movements	48	40	43	47	120	53	74	37	65
Foot movements	7	1	3	-	11	3	14	-	2
Hand-to-foot	-	-	9	-	-	1	-	-	-
Retroflexion head	11	25	20	9	10	16	10	4	23
Anteflexion head	5	6	6	2	2	7	7	9	11
Rotation head	22	26	22	12	15	17	19	9	23
Rotation fetus	8	6	7	4	9	6	3	2	7
Somersault	-	1	3	-	4	-	-	-	1
Breathing	4	7	5	2	4	1	-	1	5
Unclassified	3	11	2	6	14	-	-	-	3
TOTAL	218	255	263	180	316	251	255	160	243

Movements were classified according to the scheme proposed by de Vries, Visser and Prechtl[1] but it was found necessary to add two further types of movement – isolated foot movements and hands-to-feet. The incidence of the different types of movement is shown in Table I. For the purpose of analysis, the individual items were grouped into four clusters - those reflecting immaturity (startles, wriggles, twitches and clonus), those reflecting locomotion and propulsion (jumping, creeping and stretching), sequential and/or isolated movements (arm, fingers, hand-to-face, leg, foot, hand-to-foot) and head/trunk movements which are the precursors of righting reactions (retroflexion, anteversion or rotation of the head; rotation of the fetus, somersault) (Table II). Hiccups, breathing, sucking, swallowing and yawning were excluded from the analysis and a few movements defied classification.

TABLE II: CLUSTERED FM TYPES AT 20 WEEK GESTATION

Fetus	Imm	Loco	Seq/isol	Pre-right	Unclass	Breath	TOTAL
2	48	30	87	46	3	4	218
3	57	44	72	64	11	7	255
4	47	53	98	58	2	5	263
5	65	16	64	27	6	2	180
7	66	34	158	40	14	4	316
8	68	26	110	46	-	1	251
9	53	20	143	39	-	-	255
11	66	28	41	24	-	1	160
12	44	23	103	65	3	5	243
TOTAL	514	274	876	409	39	29	2141

TABLE III: FM TYPE AS A PROPORTION OF FM

	Mean/30 min	%
Immature movements	57,11	24,34
Loco/propulsion	30,44	12,97
Sequential/isol	97,33	41,48
Pre-righting	45,44	19,36
Unclossified	4,33	1,85
TOTAL		100

When expressed as a percentage of total movements (Table III), it is obvious that sequential and isolated movements predominate a 20 weeks' gestation. The percentage of sequential and isolated movements also appear related to the total number of fetal movements (Fig 1).

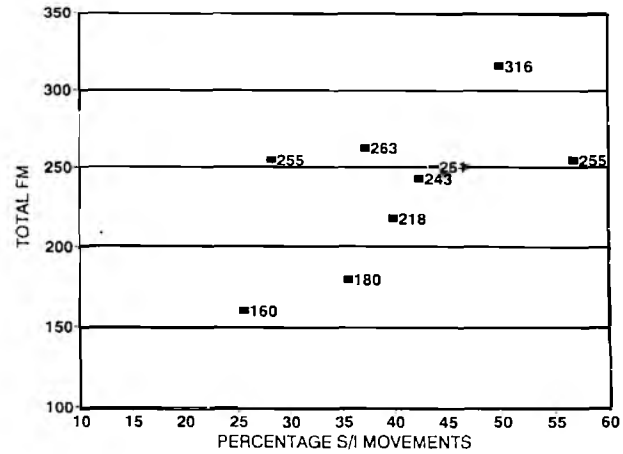

Figure 1: Relationship between sequential/isolated FM and total FM at 20 weeks gestation

Neonatal studies

The BNBAS scoring is more difficult to analyse as, although most items are scored on a scale of 1–9, the optimal score is not the same for all items (Table IV). For the purpose of analysis, items have again been clustered in related items. The groupings are tone (item 11), habituation (items 1,2,3,4), orientation and alertness (items 5,6,7,8,9,10,16), motor maturity (items 12,13,14,15,25,26,27), motor immaturity (items 21,22) and emotional responses (items 17,18,19,24).

TABLE IV: BRAZELTON NEONATAL BEHAVIOURAL ASSESSMENT SCALE SCORES

	Tone	Mot.Mot.	Mot.Imm.	Orient/Al	Resp.Dec	Emot.Res
Optimum	5-6	9	<5	9	>5	<5
2	6	8,42	3,00	8,42	6,25	3,00
3	5	8,00	3,00	7,71	7,75	4,00
4	6	7,14	3,00	8,57	7,25	2,00
5	7	4,12	4,00	3,37	6,50	4,25
7	6	6,20	7,00	5,43	4,50	5,67
8	6	5,14	3,50	7,71	6,75	4,00
9	6	7,40	3,00	6,71	6,75	1,00
11	4	4,00	4,50	3,57	6,25	4,25
12	6	4,80	4,00	6,57	5,50	4,00

Fetal movement c/f BNBAS scores

Comparison of the fetal movement and BNBAS scores (Figs 2 and 3) shows a pattern in which higher total FM scores are related to more optimal BNBAS scores, whereas low FM scores are associated with less optimal BNBAS scores, in particular with poor postural tone (high or low)(infants #5 and #11). In addition, a predominance of more mature types of fetal movement at 20 weeks appears to be associated in most instances with more optimal BNBAS scores.

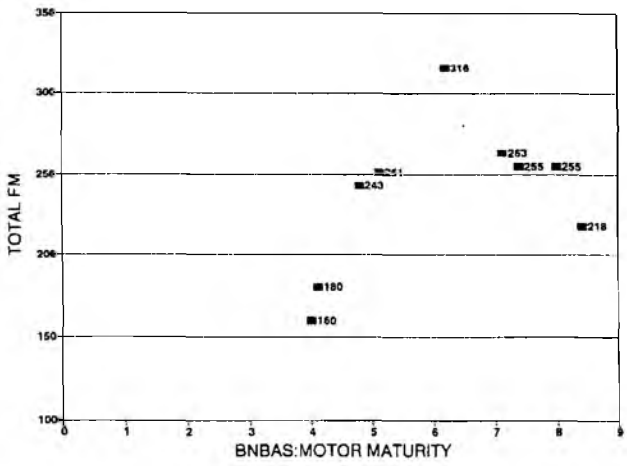

Figure 2: Total FM at 20 week gestation compared with motor maturity on the BNBAS

Comparative performances of black c/f white infants

Although the numbers are small, Table V shows a tendency to fewer immature fetal movements and more mature patterns of fetal movement among the black fetuses.

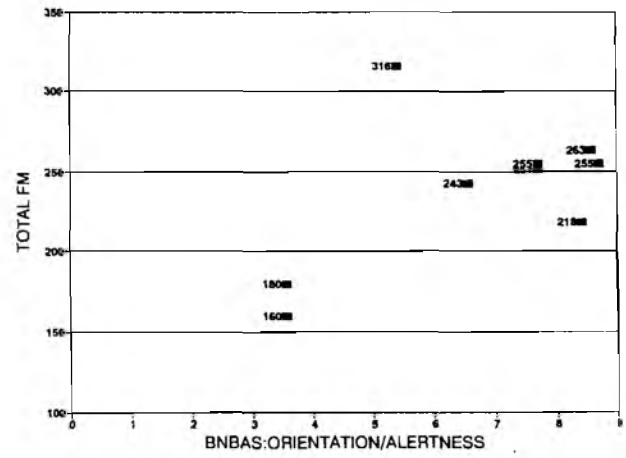

Figure 3: Total FM at 20 week gestation compared with orientation/alertness on the BNBAS

Comparative analysis of the BNBAS scores shows that the black infants were more inclined than the white infants to have optimal postural tone, a high degree of motor maturity and good orientation/alertness. They could also keep themselves calm, showing stable emotional responses and a good response decrement to afferent stimuli.

TABLE V: COMPARISON OF BLACK AND WHITE INFANTS USING MEAN SCORES

	Black (n=4)	White (n=3)
Total FM	247,75	230
% Sequential/isol	41,99	4,57
% Immature	20,76	28,69
% Loco/propulsion	14,75	11,39
% Pre-righting	20,89	17,55
% Unclassified	1,61	1,80
BNBAS		
Tone	5,75 (5–6)	5,80 (4–7)
Motor maturity	7,74	4,85
Motor immaturity	3,00	4,60
Oreintation/alert	8,35	5,37
Response decrem	7,00	5,90
Emotional response	2,50	4,43

Discussion

Comparison of the total incidence of movements recorded with that found in previous studies is difficult, partly due to the paucity of studies at 20 weeks' gestational age and partly due to differences in documenting the incidence of movements. De Vries, Visser and Prechtl[2] found the mean longest pause between movements, calculated over 12 fetuses at 19 weeks, to be 127 seconds. This correlates with the present study, where no 3-minute window was empty of movements. The total movements in their study[1] cannot be calculated accurately as rates are given separately for different types of movement and not all types are included, but it would appear that the incidence of fetal movements is higher in the current study. De Vries comments that the incidence of isolated arm movements, recorded in 12 fetuses over a period of one hour,

increased steadily from 8 to 19 weeks. This correlates well with the incidence noted in this pilot trial. In contrast, however, he noted that the incidence of isolated leg movements was much less, whereas in the present study the incidence of isolated leg movements greatly exceeded that of isolated arm movements, averaging 63 over the 30 minutes recording period.

The average number of movements occurring over the 30 minute recording period in the black fetuses was 247,75, as compared with 230 in the white infants. As mentioned earlier, one fetus was excluded from the analysis due to epilepsy in the mother. This was only identified during the neonatal testing when the infant was noted to be abnormally drowsy. Enquiry revealed that the mother was epileptic and her medication had been doubled during labour. If her fetal movement count is included in the analysis, the discrepancy in the average number of movements between black and white fetuses becomes even more apparent.

With the exception of one white mother who had the highest fetal movement count (316) but a very jittery newborn infant, higher fetal movement scores correlated with better BNBAS scores, in particular those related to motor maturity and to orientation/alertness. It is particularly noticeable that the two white infants who received the lowest fetal movement scores also achieved poor scores for postural tone coupled with low scores for both motor maturity and orientation/alertness. Although Shadmi *et al* (1986) found no correlation between fetal movement and the motor activity of neonates, they did not use ultrasound scanning and instead relied on maternal recording of fetal movement[15]. They also only used ten items from the BNBAS in their neonatal studies, based primarily on orientation and alertness. In particular they did not score postural tone.

Although trends have been identified relating number and type of fetal movement to performance on the BNBAS, as well as indicating the presence of more mature types of fetal movement and better performance on neonatal testing in black infants, no statistical significance can be shown due to the small sample size in the pilot trial.

In the main trial 20 black and 20 white mothers will undergo ultrasound scanning at 16 and 20 weeks' gestational age. The BNBAS will be performed on day two post birth and will be repeated at four weeks of age. The gross and fine motor items of the Denver Developmental Screening Test, adapted for the Cape Town norms[26,27], will be administered at 4,8 and 12 weeks of age, accompanied by videotaped recordings of posture and movement at each age.

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