Effect of intervention on development of hip posture in very preterm babies

J A Downs, A D Edwards, D C McCormick, S C Roth, A L Stewart

Abstract

Preterm babies are physiologically hypotonic, which causes their posture to be flattened when lying in the prone position. This flattened posture may persist beyond term. In a prospective, randomised, controlled, double blind trial of postural support carried out on 45 babies born at less than 33 weeks of gestation, we showed that infants positioned with specific hip support during the period of intensive care had significantly fewer features of flattened posture at the age equivalent to term.

Extremely preterm babies, especially those who are very sick, demonstrate physiological muscle hypotonia.^{1 2} When placed in the prone position they tend to lie without pelvic elevation so that the trunk and pelvis are flat on the cot, with the lower limbs abducted and externally rotated and the hips flexed to greater than 90°. Grenier observed that prolonged lying in this position resulted in a flattened posture which he termed 'frog lying'.³ He proposed that the prolonged, excessive hip flexion resulted in shortening of the iliopsoas and adductor brevis muscles, a process that may be reversed when normal movement develops. In the neurologically abnormal infant, normal movement may not occur and the shortening may persist leading to scissoring. Grenier's hypothesis implies that some of the consequences of neurological impairment could be ameliorated by preventing the postural abnormality of the legs.

It is difficult to test this hypothesis directly because seriously neurologically impaired infants are relatively uncommon among survivors of neonatal intensive care.⁴ We therefore designed a study of very preterm infants admitted consecutively to a neonatal intensive care unit to investigate whether maintaining functional postures during hospital admission prevented the development of the 'frog lying' or flattened posture.

Patients and methods

Consecutively born infants of less than 33 weeks' gestation, who were born at University College Hospital and admitted to the neonatal unit, were enrolled in the trial providing they were without genetic anomalies or congenital limb abnormalities.

Consent was obtained from the parents before entry into the study and the project was approved by the University College London faculty of clinical sciences committee on the ethics of clinical investigation.

A prospective, randomised, double blind, controlled trial was conducted. Randomisation was performed using random number tables. Preliminary calculations indicated that 20–25 subjects were needed for each group to detect a reduction in the incidence of flattened features of posture from 50% to 10% with significance at the 5% level.

PRELIMINARY STUDY

A preliminary study was conducted before the commencement of the trial in order to identify the specific features of posture of full term infants. Twenty five infants born at University College Hospital with a median gestational age of 40 weeks (range 37–42 weeks) and judged to be medically well, were examined at a median age of 4 days (range 3–14 days). These findings provided a precise definition of posture in the prone and side lying positions which were used as the normal standards to judge the success of the postural treatment in the study (see below).

TREATMENT GROUP

Specific positioning for the treatment group commenced when the infants reached 7 days of age and continued until a gestational plus postnatal age of at least 36 weeks (the age at which active muscle tone begins to develop¹) or until discharge home.

When lying prone the babies were positioned with some pelvic elevation, the lower limbs bearing weight through the anterior knee and the hips not flexed to greater than 90° (fig 1A). In the side lying position the trunk was supported so that it was perpendicular to the cot surface with both arms comfortably forward and the bottom leg in neutral rotation (fig 1B). In the supine position both knees and elbows were supported off the cot surface to reduce hip and shoulder abduction (fig 1C). Rolled sheets or bean bags were used to support the infants. The positioning of the babies was implemented and supervised by the neonatal physiotherapist (JAD).

CONTROL GROUP

The control group was nursed according to usual nursing practice for the unit. The prone position without hip support was favoured. When in the side lying position the infants were sometimes supported with a rolled sheet or blanket but without specific attention to the line of the trunk or the position of the lower leg. No knee or elbow support was provided for the infant in the supine position.

Department of
Physiotherapy,
University College
Hospital,
London
J A Downs

Department of
Paediatrics,
University College and
Middlesex School
of Medicine,
London
A D Edwards
D C McCormick
S C Roth
A L Stewart

Correspondence to:
Ms J Downs,
c/o Ms Jan Townsend,
Department of Paediatrics,
University College and
Middlesex School of Medicine,
Rayne Institute,
University Street,
London WC1E 6AU.
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Figure 1 Postural support provided for the treatment group infants when in the (A) prone, (B) side lying, and (C) supine positions.

FOLLOW UP ASSESSMENT

Infants were assessed at a gestational plus postnatal age of 40 weeks by paediatricians during the course of neurological examination in the follow up clinic. The infants were undressed, in a quiet alert state, and medically well. The examiners, who were unaware of the group to which each baby had been assigned, performed a neurological examination¹ and a postural assessment. Each examiner had previously been trained in the assessment procedure and interobserver reliability was checked.

The postural assessment was divided into three sections:

(1) Prone lying

The baby was placed in the prone position and the weight bearing surface of the lower limb was observed. This was recorded as passing through the anterior knee, the medial knee, or the medial thigh and knee, the former category representing those babies who lay with pelvic elevation (normal) and the latter two representing those whose posture was flattened (abnormal).

(2) Side lying position

The infant was placed in a side lying position. If the infant could maintain this position independently it was recorded as stable (normal) and if not as unstable (abnormal).

(3) Supported standing

The infant was supported standing in a tray of Provil-p-base (Bayer UK Limited, Dental Products Group), a soft and non-abrasive putty, which deformed under the infant's weight to

leave footprints. The line joining the tip of the first toe and the posterior aspect of the heel was defined and deviation from the position of neutral rotation was measured (fig 2).

STATISTICAL METHODS

Results in the prone and side lying positions were analysed using the χ^2 test with Yates's correction. The angles of total leg external rotation in the supported standing position were analysed using the Mann-Whitney U test.

Results

Eighty five infants were considered for the study. Three infants were ineligible for admission because of lower limb orthopaedic abnormalities and six parents did not consent to their babies being admitted to the trial. A total of 76 infants were therefore enrolled. Of these, 31 infants who had been enrolled in the study were subsequently excluded. Three study infants

Figure 2 The point of the heel (a) and first toe (b) were marked and this was taken to represent the line of the first toe. The angles between the line of the first toe and the position of neutral rotation were measured and added to give the total number of degrees of external rotation of the legs.

Clinical details of the treatment and control groups

	Treatment group			Control group		
	Total (n=21)	24–28 weeks (n=10)	29–33 weeks (n=11)	Total (n=24)	24–28 weeks (n=9)	29–33 weeks (n=15)
Male:female	10:11	5:5	5:6	12:12	5:4	7:8
Median birth weight (g)	1332	965	1484	1252	852	1500
Range	664–2079	664–1379	965–2079	703–2180	703–1403	925–2180
Delivery:						
Vaginal	9	6	3	6	5	1
Caesarean	12	4	8*	18	4	14
Median No of days on mechanical ventilation	4	4	2	2	3	2
Range	0–26	1–26	0–10	0–25	1–25	0–8
Median No of days oxygen dependent	9	13	6	6	26	5
Range	0–182	2–182	0–73	0–108	2–108	0–34
No with abnormal neurological examination at term	12	6	6	14	8	6

*One of these infants was a breech presentation.

died (they had been allocated to the control group), three infants in the treatment group were not positioned as specified by the protocol for a period of three weeks, and 16 infants in the treatment group were transferred to another hospital or discharged home before reaching a postnatal plus gestational age of 36 weeks. Nine infants were not assessed before reaching a gestational plus postnatal age of term plus four weeks (three had been allocated to the treatment group and six to the control group) because they remained unwell in the intensive care unit or did not attend the follow up appointment. Forty five infants completed the trial, 21 in the treatment group and 24 in the control group. Clinical details are given in the table.

All 45 infants were assessed at a gestational plus postnatal age of 37–44 weeks (median 40 weeks) and the results of the posture assessment were as follows:

(1) Prone lying

Eighteen of 21 infants in the treatment group and seven of 24 in the control group lay with weight taken through the anterior surface of the knee; the remaining babies lay with weight taken through the medial knee or the medial

Figure 3 Histogram showing the results of the assessment of posture in the prone position for the treatment and control groups. Normal indicates those who lay with weight taken through the anterior knee and abnormal those who bore weight through the medial knee or leg.

surface of the leg. There was a significant difference between the control and treated group ($p<0.0005$). Separate analysis of the infants born at 24–28 weeks' gestation showed a significant difference between the groups ($p<0.001$) whereas there was no difference among infants born at 29–33 weeks' gestation (fig 3).

(2) Side lying position

Eighteen of 21 infants in the treatment group and nine of 24 in the control group were stable. The difference between the two groups was significant ($p<0.005$). Separate analysis of infants born at 24–28 weeks' gestation showed a significant difference between the groups ($p<0.05$) whereas there was no difference among infants born at 29–33 weeks' gestation (fig 4).

(3) Supported standing

Figure 5 shows the measured angles of external leg rotation for the treatment and control groups. The median value for the treatment group was 33° with a range of 0–120°. The median value for the control group was 40° with a range of 0–105°. The treatment group had sig-

Figure 4 Histogram showing the results of the assessment of posture in the side lying position. Normal indicates those who were stable in the side lying position and abnormal those who were unstable.

Figure 5 The angle of total leg external rotation as measured in supported standing is shown for each infant in the treatment and control groups.

nificantly smaller angles than the control group ($p < 0.01$).

Discussion

We have observed the development of flattened posture among very preterm infants, particularly those who were extremely preterm or very sick and had been nursed conventionally while undergoing neonatal intensive care. The posture was characterised by a lack of pelvic elevation in the prone lying position, excessive hip flexion, and the inability to maintain the side lying position. Other investigators have recorded similar findings. Updike *et al* described features of nursery acquired positional disorders corresponding to the flattened posture.⁵ In a longitudinal study of the development of leg posture in a group of preterm babies of 25–35 weeks' gestation, Lacey *et al* found that in the prone position, 35% were weight bearing through the medial knee or leg when examined at a gestational plus postnatal age of 35–38 weeks.⁶ This finding was associated with chronic oxygen dependence. By contrast, the full term lies with limbs semiflexed.⁷ In the preliminary study of term infants conducted before the trial, we too noted this typical semiflexed posture. When the infants were in the prone position, there was pelvic elevation and the anterior knee bore the weight of the lower body; the full term infants were stable in the side lying position.

Grenier has drawn attention to the excessive hip flexion which is associated with the flattened posture.³ He has suggested that this may cause shortening of the iliopsoas and adductor brevis muscle because excessive hip flexion brings the origin and insertion of these muscles closer together, and immobilised muscle adapts to the imposed length by shortening of individual sarcomeres.⁸ In a child with normal neuromotor function, this deficit will be remedied with the onset of normal movement. However, a child with neurological impairment

may not move adequately and will therefore be unable to overcome the muscle shortening. This could result in scissoring in the upright position, therefore affecting the stability of the hip joint and interfering with the development of walking. Grenier proposed that maintaining functional postures during neonatal intensive care would prevent this sequence of events.

Our results show that postural treatment, designed to maintain the positions noted in full term infants, can reduce flattening in very preterm infants. The postural techniques used were compatible with the infant receiving intensive care, inexpensive, simple and readily accepted by the nursing staff in the neonatal unit. The effect was significantly more noticeable in the most vulnerable infants: those born at 24–28 weeks' gestation. These infants are likely to be sick and to require mechanical ventilation and added oxygen when their muscle tone is poorly developed. It is therefore particularly gratifying that flattening was virtually abolished in the treated group. Infants born at 29–33 weeks' gestation were perhaps less likely to develop a flattened posture because of a shorter time period over which they were ill with poorly developed muscle tone. We therefore recommended that the neonatal physiotherapist's time be used to advise on and supervise the positioning of the infants in the younger gestation group.

The infants studied were typical very preterm infants undergoing intensive care in a regional referral centre. Many were very sick requiring oxygen treatment and mechanical ventilation (table). About half were judged to be neurologically abnormal at the gestational plus postnatal equivalent age of term according to standardised criteria¹ in both the treatment and control groups. On the basis of previous experience about 20% of the neurologically abnormal infants (8% of total) may be expected to present with serious neuromotor impairment causing disability by a corrected age of 12 months.⁹ If Grenier's hypothesis is correct, postural support could therefore be expected to ameliorate some of the consequences of impairment in neurologically abnormal survivors of neonatal intensive care. Further follow up is in progress to assess any longer term benefits of physiological positioning for the neurologically abnormal infant. It could also be expected to help all infants by enabling them to lie comfortably on their sides. This is often the favoured position for sleep and may encourage midline orientation.⁵

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Commentary

POSTURAL DEFORMATION OF THE NEWBORN

Very preterm infants, and particularly those of less than 28 weeks' gestation, are very vulnerable to mechanical deformation because of the plasticity of their skeleton, the weakness and hypotonicity of their muscles, and the rapidity with which they are growing. In normal circumstances in utero they are protected from extrinsic pressures by the amniotic fluid which cushions them, makes them weightless, and permits frequent change of posture and position. After delivery they are deprived of this protection and exposed to the influence of gravity which dominates their feeble musculature and presses them statically onto the surface on which they are lying. Deformation may result especially if the infant's posture is persistent. Typically the head falls to one side and becomes flattened. With prone or supine nursing both the thorax and pelvis may also become flattened in the anterior-posterior diameter and the thighs, which usually assume the frog position, may then become externally rotated giving the lower limbs a 'Charlie Chaplin' stance.

Many of these deformities, and other less common ones, steadily diminish as the muscular-skeletal system strengthens and the infant exercises and becomes mobile. However, they *may* persist and more research is urgently required to explore and assess their long term significance. For this reason the paper on the development of hip posture by Ms Downs and

her colleagues is to be welcomed, though their conclusions as to what positions and postures are 'normal' or 'abnormal' must be treated with reservation. It must be emphasised that no weight bearing posture can be considered normal for the extremely premature infant and what may be gained on the swings of one posture may be lost on the roundabouts of another. For example, when infants lie prone the authors advocate the attainment of pelvic elevation by weight bearing through the *anterior* (rather than medial) knee. To achieve this the thighs must be adducted (fig 1A). The weight of the lower body will then be transmitted to the thigh through the head of the adducted femur lying against the weak labrum and capsule of the hip joint. It remains to be seen whether or not such a posture will be associated with any increase in hip pathology. Certainly, swaddling infants with the legs in adduction and extension has a well recognised association with dislocation of the hip, and the frog position is that normally adopted for the treatment of this condition. Yet another potential hazard of adduction of the legs in the prone position is deformation of the weight bearing forefoot to produce metatarsus varus or valgus. This tiresome deformity, which was very rare in the days when British babies were all nursed supine, has now become common among prone preterm infants, unless nursed in the frog position.

In summary, this is a subject that requires further investigation, but in the meantime paediatricians and neonatal nurses should be aware of the problem and take appropriate measures to avoid deformation, including frequent changes in posture so that weight bearing forces are never allowed to persist for any length of time in one direction.

P M DUNN
Department of Child Health,
Southmead Hospital,
Southmead Road,
Bristol BS10 5NB