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Effect of a postural support nappy on 'flattened posture' of the lower extremeties in very preterm infants

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Objective: To determine whether the use of a postural support nappy (PSN) would reduce the features of 'flattened posture' in the lower extremities of infants <31 weeks gestation who are nursed prone.

Methodology: Randomized, observer blind, controlled trial conducted at King Edward Memorial Hospital for Women, Perth, Western Australia. Infants were randomly assigned and stratified by gestational age to be nursed in a conventional nappy ($n = 29$) or a PSN ($n = 31$) when in the prone position. The features of 'flattened posture' were measured as angles and assessed by blinded observers prior to commencement of the intervention, 4 weeks post intervention, then bi-weekly until discharge.

Results: A significant reduction in the features of 'flattened posture' occurred in the PSN group after 4–6 weeks of intervention and stabilized by 8 weeks until discharge. No changes were detected in the control group. No significant difference was observed between infants <29 weeks gestation compared to infants of 29–30 weeks gestation in either treatment group.

Conclusions: Use of the PSN in infants <31 weeks gestation who are nursed in the prone position significantly reduces the features of 'flattened posture' in the lower extremities. This is of benefit in the short term, and follow up of these infants into childhood will demonstrate whether the long-term effects of 'flattened posture' can be prevented.

Key words: flattened posture; infant; postural support; very preterm.

In many neonatal units worldwide, preterm infants are routinely nursed in the prone position.[1–3] This position is reported to have many beneficial effects, including increased lung compliance and tidal volume, increased rate and regularity of breathing, decreased asynchronous chest wall movement, decreased energy expenditure, increased partial pressure of oxygen, and time spent asleep.[4–7]

At birth, preterm infants are removed from a uterine environment that permits frequent changes of position and the development of normal posture, to an environment that inhibits positional change. This diminished opportunity for positional change together with physiological hypotonia, places the infant at risk for the development of postnatal positional abnormalities. Of these, one in particular affects the lower extremities resulting in the development of 'flattened posture'.[8,9] This is characterized by external rotation and wide abduction of the lower limbs, hip flexion of greater than 90° and lack of pelvic elevation.[10] This posture can be disadvantageous for the weight-bearing forefoot, leading to delays during the first year in motor skills such as walking, crawling and sitting.[11] It can also have longer term implications as affected infants will often 'toe walk' for up to 18 months of age.[11,12] 'Flattened posture' can also cause abnormal gait patterns which may be cosmetically displeasing.[13]

Appropriate positioning of the lower limbs during intensive care has been suggested as an effective means of preventing this postural abnormality.[10,11,14–16] We have used a postural support nappy (PSN) to promote elevation of the pelvis and flexion of the lower extremities (Fig. 1). The cloth nappy was folded to provide more support under the pelvis.

The aim of this study was to investigate whether nursing the preterm infant in a postural support nappy while in the prone position altered the features of 'flattened posture', namely: (i) a decrease in the weight bearing surface of the inner surface of the thigh and knee; (ii) a decrease in the angle of external rotation of the leg; and (iii) an increase in the angle of elevation of the pelvis.

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METHODS

A randomized, controlled, observer blind trial was conducted over a 9 month period during 1993 in the NICU of the major neonatal tertiary referral centre of Western Australia. Infants were randomized to a postural support nappy group or a control nappy group. All infants <31 weeks gestation who were required

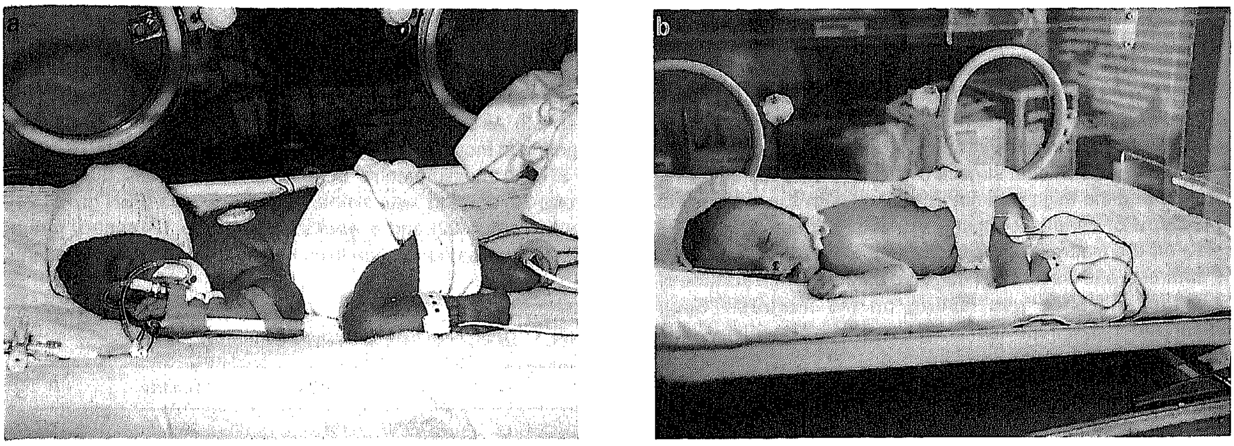

Fig. 1 (a) Infant of 30 weeks gestation wearing a conventional nappy. External rotation of the hips and legs, lack of pelvic elevation and an increased area of weight bearing of the inner surface of the thigh and knee are evident. (b) Infant of 30 weeks gestation wearing a postural support nappy. Pelvic elevation is provided by a double fold under the pelvis and external rotation of the hips and legs is prevented by reduced bulk between and around the legs. In addition, flexion of the lower extremities is promoted, producing a reduced area of weight bearing of the inner surface of the thigh and knee.

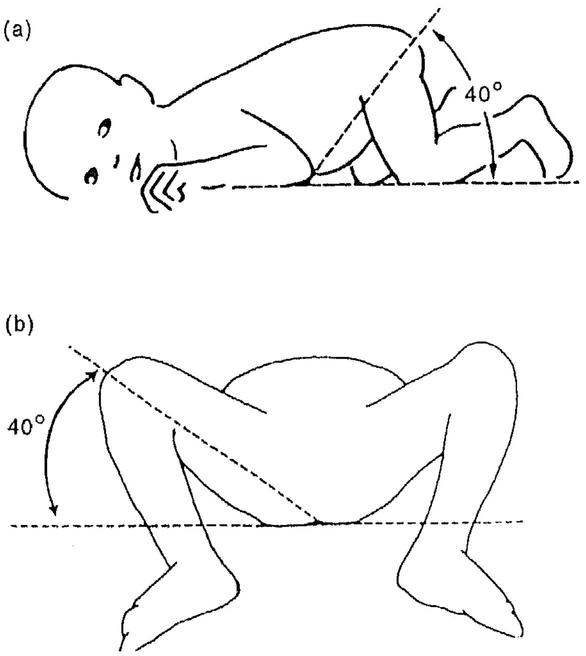

Fig. 2 (a) Angle of pelvic elevation in prone = angle between the mattress and line from xiphisternum to centre of hip joint. (b) Angle of leg rotation from lateral support in supine = angle between mattress and end of anterior surface of patella. (Figure 2(a), (b) printed with kind permission from Joan L Lacey).

to be nursed prone were eligible for randomization. Infants were excluded if they had any congenital or postnatally acquired condition which affected the development of normal posture. Randomization was stratified by gestational age at delivery into one of two sub-groups: <29 weeks gestation or 29–30 weeks gestation. Infants were commenced in the study as soon as their condition permitted prone positioning and application of a nappy.

Both the PSN and control nappy used in this study were the regular cloth nappies which are routinely applied to all infants in the trial nursery. The PSN was a triangular cotton nappy folded in such a way that when placed on an infant, it resulted in a double fold under the pelvis which provided pelvic elevation. External hip rotation was prevented by a reduction in the amount of nappy bulk between and around the legs. The overall effect enhanced mobility of the infant's legs (Fig. 1). Nappies applied to the control group were folded according to routine nursing practice. The duration of the intervention ranged from 4 to 14 weeks and was dependent both on the gestational age of the infant and the time until the infant's condition permitted routine side-lying.

Measurements of hip posture in both groups were made by observers blinded to the infant's group assignment. They were recorded at the start of the intervention, at 4 weeks of age and thereafter bi-weekly until the infant's discharge. Strictly standardized measurements were used and included the weight bearing surface of the inner thigh and knee in prone, the angle of elevation of the pelvis in prone (EP), and the angle of external rotation of the leg (RL) from lateral support in supine (Fig. 2).[2] Since there is usually no significant difference in range of motion between the right or left leg, the right leg was used for all measurements.[17–18] Accurate examination of infants was also dependent on muscle tone; therefore, all measurements were performed midway between feeds when infants were neither too hungry nor too sleepy.[2]

As recommended by Lacey *et al.*[2] if unstable breathing patterns were observed, observations were postponed until the posture was stable again for 2 min. The EP angle was assessed in the prone position as the angle between the mattress and a line from the xyphisternum to the centre of the hip joint. The infant was placed in the mid-supine position for the RL angle measurement where stabilization of the head in the midline was ensured to prevent the possible influence of the asymmetrical tonic neck reflex. The RL angle was defined as the angle between the mattress and the anterior surface of the patella. This measurement, therefore, was not influenced by the presence of tibial torsion. A plastic, 180° goniometer marked in 5° increments, with a perspex arm, was used for the EP and RL measurements. The goniometer was reliable with an interrater reliability of $r = 0.977$, $P<0.05$. The Lacey grading scale was used to assess the area of weight-bearing surface (WBS) of the inner thigh and knee. This scale consisted of three grades where a score of 3 indicated that the anterior surface of the knee only rested on the mattress and the thigh was not in contact with the mattress at all, a score of 2 indicated that the medial aspect of the knee rested on the mattress and part of the thigh was raised above the mattress, and a score of 1 denoted that the entire surface of the thigh and knee was resting on the mattress. Each measurement was repeated 3 times with the median value recorded.

Statistical analysis

It was estimated that 30 babies in each group would have an 80% power with a Type 1 error rate of 5%, to show a significant difference of 75% of the standard deviation in any of the measured angles between the PSN group and the control group. Analyses were two-tailed with an α of 0.05. Differences in clinical baseline details between the PSN and control groups were analysed using paired *t* tests if data were normally distributed; if not, Wilcoxon rank sum tests were used. For categorical variables with two levels Fisher's exact test was used, otherwise a Chi-squared test was used. Differences in the EP and RL angles between groups at each time point up to 8 weeks were analysed using repeated measures analysis of variance. Contrasts and Helmert's transformations were used to define discontinuities and to determine the point at which the treatment effect of the PSN reached a plateau.

Multivariate analyses of variance were performed to control for possible confounding variables such as sex, gestational age and days of supplemental oxygen. For the ordinal measure of the weight-bearing surface, differences in each group at each time point (4, 6 and 8 weeks) were analysed using the Wilcoxon paired rank sum test. Differences in measurements between the PSN and control groups at each time point (4, 6 and 8 weeks) were analysed using the Wilcoxon rank sum test.

Ethical approval

The study was approved by the Institutional Ethics Committee and written consent was obtained from parents at the time of enrolment.

RESULTS

Sixty-eight infants were randomly assigned to either the PSN ($n = 36$) or control ($n = 32$) group. Eight participants (PSN group 5, control group 3) were subsequently excluded from the study as two of these died from complications of prematurity, three developed periventricular leukomalacia with a grade 4 intraventricular haemorrhage, and two were diagnosed with congenital disorders which would affect the development of normal posture. One participant was withdrawn from the control group at the request of the parents who wished their infant to be nursed exclusively in the postural support nappy. There were no differences in clinical details between the two groups at birth (Table 1) nor in the postnatal period (Table 2). The eight infants who were excluded showed no difference at birth from those remaining in the trial. The baseline measurements of the hip angles and weight-bearing surface also showed no differences (Table 3). As seen in Fig. 3 the PSN group showed a statistically significant increase from baseline for the EP ($P = 0.02$) and RL ($P = 0.02$) measurements at week 4 (PSN group 30, control group 29) and this was maintained at 6 weeks (PSN group 24, control group 22) and 8 weeks (PSN group 17, control group 15). There was no change from baseline in either angle at any

Table 1 Differences between groups for birth variables

	PSN		Control		*P*
n	31		29		
Gestational age*	27	(26–29)	28	(27–29)	0.326
Gestational age group†					
29–30 weeks	12	(38)	14	(48)	
Birthweight‡	1057	(249)	1102	(275)	0.593
Male Sex†	19	(62)	19	(66)	0.793
Delivery†					1.000
LUSCS	15	(48)	15	(48)	
Spontaneous	16	(52)	14	(52)	
Presentation†					0.435
Vertex	21	(68)	16	(55)	
Breech	9	(29)	10	(35)	
Other	1	(3)	3	(10)	

*Median (interquartile range).
‡Mean (s.d.).
†*n* (%).

Table 2 Differences between groups for postnatal variables

Variable	PSN		Control		*P*
n	31		29		
Septic episodes*	2	(1–3)	2	(1–3)	0.751
Ventilated days*	14	(2–39)	6	(2–26)	0.252
Oxygen days*	22	(3–43)	6	(0–35)	0.295
IVH†					0.278
Grade 0	13	(42)	18	(62)	
Grade 1–2	17	(55)	10	(35)	
Grade 3	1	(3)	1	(3)	
Discharge oxygen†	1	(3)	2	(7)	0.606

*Median (interquartile range).
†*n* (%).

Table 3 Distribution of baseline measurements

Variable	PSN	Control	*P*
Angle of pelvic elevation in prone*	36 (8.4)	37 (8.6)	0.606
Weight bearing surface of the leg in prone†	2 (1–2)	2 (1.5–2)	0.643
Angle of external rotation of the leg from lateral support in supine*	33 (6.8)	35 (7.4)	0.477

*Mean (s.d.).
†Median (interquartile range).

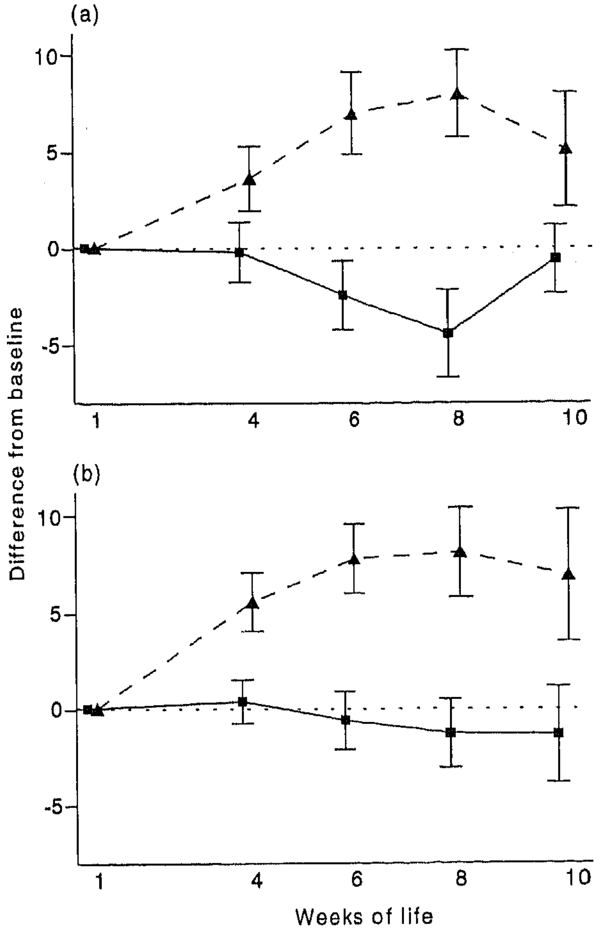

Fig. 3 Mean and standard errors for changes from baseline in angles of (a) elevation of the pelvis and (b) external rotation of the leg in the PSN group (▲) and control group (■).

time point in the control group. There was a significant reduction in the weight-bearing surface of the PSN group of infants by 6 weeks (median 0, IQ range 0–1, $P = 0.03$) and this was maintained at 8 weeks (median 0, IQ range 0–1, $P = 0.02$). There were no differences in the control group at 4 weeks (median 0, IQ range 0–0.5, $P = 0.86$), 6 weeks (median 0, IQ range 0–0, $P = 1.00$) or 8 weeks (median 0, IQ range 0–1, $P = 0.106$). Multivariate analysis of variance showed no effect on the changes in angles from any of the clinical variables, nor of gestational age group, type of delivery or presentation at delivery.

DISCUSSION

The prevention of the 'flattened posture' which develops in very preterm infants when nursed prone may be important for the longterm outcome of these infants. Because of the preterm infant's immediate survival needs, focus has been placed on the infant's short term clinical status with little focus on the prevention of this postural problem. The results of this study are among the first in the area of preterm infant posture and have highlighted the need for carers to consider the longer term outcome for these infants.

There is only one other report by Downs *et al.*[10] on the use of postural supportive techniques which examined the effect of a specific intervention on the development of hip posture. This randomized, controlled trial was carried out on 45 infants of ≤34 weeks gestation and used supportive positioning techniques (rolled sheets or beanbags) for prone, side-lying and supine placement. The findings demonstrated that 'flattening' was virtually abolished in the group of most vulnerable infants of 24–28 weeks gestation, and infants born at 29–34 weeks were less likely to develop 'flattened posture' because of the shorter time period over which they were ill with poorly developed muscle tone. Use of these postural supports has been criticized as they may lead to an increase in hip pathology, an example of which is dislocation of the hip resulting from adduction and extension of the legs. An added concern regarding the use of these postural supports was the possible restriction of mobility which may impede normal postural development.[9,14]

The present research has used a postural support nappy which lacked the disadvantages associated with the postural supports used in the Downs *et al.* study.[10] Furthermore, care was taken to ensure accuracy and reliability of all measurements used in this study. The goniometer which was used to measure the two hip angles is the most widely used evaluation tool in physical therapy, and is frequently used in the measurement of hip rotation in neonatology.[2,17–21]

In an effort to reduce the features of 'flattened posture', the PSN was used in this study to prevent external rotation and wide abduction of the hips and promote mobility and flexion of the lower extremities. The findings showed that the infants in the PSN group showed an increase in the angle of elevation of the pelvis and a decrease in the angle of external rotation of the leg from baseline at 4, 6 and 8 weeks. Furthermore, these infants showed a reduction in the weight-bearing surface of the leg from 6 to 8 weeks. In contrast, infants in the control group showed no improvement from their baseline measurements for any of the measurements at any time point.

Although it was not our intention to observe the effect of the PSN on mobility and positioning, it was of interest that an increase in mobility of the lower extremities was observed by nurses caring for the infants wearing the PSN. Ease in positioning these infants unsupported and on their side was also identified as a positive effect of the PSN when compared to infants who wore the conventional nappy.

The present findings indicate that the PSN led to a reduction in the features of 'flattened posture' and it would be reasonable to suggest that the PSN be utilized when caring for very preterm infants. It is important that the nappy be applied as soon as an infant is placed in the prone position, providing its condition is stable. In addition, to ensure maximum benefit PSN nappy application should continue for at least 4–6 weeks until prone positioning ceases. Since stability of the increased hip angles occurs after 6 weeks, application of the PSN may not be essential after this time. Furthermore, it is important to note that in many instances, prone positioning may routinely cease between 4 and 8 weeks. When infants cease prone positioning and commence routine side-lying, there is no value in applying the PSN since side-lying is a preventative measure for the development of 'flattened posture'. Long-term follow up of these infants is being conducted to examine whether there are any differences between the groups when walking commences.

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