



Developmental Dysplasia of Hip and Post-natal Positioning: Role of Swaddling and Baby-Wearing

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Abstract

Introduction Traditional swaddling, which implies restrictive immobilisation of the infant’s lower limbs with the hips in forced extension and adduction, has been shown to be a risk factor for Developmental Dysplasia of Hip (DDH).

Methods We reviewed the literature regarding the correlation between DDH and post-natal positioning by swaddling and baby-wearing, to draw awareness of healthcare professionals towards an important risk factor for DDH that has often been overlooked.

Results There is overwhelming evidence in the literature, by both experimental and clinical studies, that proves the close association between improper post-natal positioning of the baby’s hips in extension-adduction and an increased incidence of DDH. On the other hand, “hip safe” swaddling which allows unrestricted flexion-abduction movements of the infants’ hips, and the use of baby-wearing devices which keep the lower limbs in an attitude of hip flexion-abduction and knee flexion, is optimal for hip development. Populations which practice these “hip-safe” techniques of infant immobilisation have a lower incidence of DDH as compared to those which practice restrictive immobilisation. Furthermore, populations which have adopted “hip-safe” positioning have demonstrated a significant decrease in the incidence of DDH. Understanding this association is vital, since this is a modifiable risk factor, rectification of which can decrease the incidence of DDH.

Conclusion Policy makers and governments must design educational campaigns tailored to their respective populations to increase awareness regarding the benefits of “hip-safe” techniques of infant positioning, since this simple intervention has the potential of decreasing the incidence of DDH.

Keywords Developmental dysplasia of hip · DDH · Swaddling · Baby-wearing · Hip-safe · Post-natal positioning

Introduction

Developmental dysplasia of hip (DDH) encompasses a spectrum of conditions including hip dysplasia, subluxation, dislocatable hip, reducible and irreducible dislocations. First-born child, female sex, positive family history, oligohydramnios, twin pregnancy, uterine anomalies, post-maturity birth, and birth weight > 4 kg are recognized risk factors for

DDH [1–4]. Whereas female sex and family history indicate the role of genetic and hormonal factors in the causation of DDH, all other risk factors implicate intra-uterine overcrowding and fetal positioning.

In addition to the above, post-natal positioning is now recognized to be contributory to the causation of DDH [5]. Traditional infant swaddling methods or methods of baby carrying, in which the infant’s lower limbs are forced into hip extension-adduction and knee extension, are detrimental and predispose to hip dysplasia [6–9]. On the other hand, “hip-safe” swaddling and carrying infants in baby-wearing devices which permit unrestricted hip flexion-abduction and knee flexion, facilitates normal hip development [10–12]. Recognizing the association between post-natal positioning and the occurrence of DDH is especially important, because these are “modifiable” risk factors. Creating awareness amongst healthcare workers and caregivers regarding

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“hip-safe” techniques of post-natal positioning can potentially decrease the incidence of DDH in society [13–15].

In this article, we review the literature on two widely prevalent methods of post-natal positioning, namely, infant swaddling and use of baby-wearing for infant carrying, in order to draw awareness of healthcare professionals towards an important risk factor for DDH that has often been overlooked.

Relevant Biomechanics of the Infant Hip

The attitude of the lower limbs of the foetus throughout pregnancy is one of hip and knee flexion, except for the rare frank breech presentation in which the hips are in flexion and knees in extension. Due to this, all typically developing infants have physiological flexion-external rotation contractures of the hips and flexion contractures of the knees at birth. The hip flexion deformity ranges from 20° to 60° at birth. These contractures gradually resolve spontaneously and by the age of 4 months, the hips and knees can usually be passively extended to neutral [16–18].

Attempts to forcibly correct the hip and knee physiological flexion contractures may predispose the infant’s hip to DDH. Stretching of the contracted iliopsoas, hamstrings and hip abductors as they traverse the hip joint result in abnormal joint reaction forces across the hip joint, which may result in dysplasia. In an animal study performed on 85 growing rabbits, Michelsson et al. [19] immobilised 1 or both knees in extension. In almost all immobilised rabbits, subluxation, dislocation or dysplasia of the hips, reminiscent of changes of DDH seen in humans, was observed. Rabbits in whom the extension immobilisation was continued for a prolonged period developed permanent dislocation. However, changes in the hip failed to develop in a subgroup of animals in whom the hamstrings were transected before extension immobilisation of knees. These observations prompted the authors to conclude that tension in hamstring group of muscles as they traverse the hip joints is responsible for dislocation or dysplasia of the hips [19].

In an experimental study conducted on a computational model of a 1-year-old infant’s lower extremities, the joint reaction forces across the hip joint in varying degrees of flexion and abduction were assessed [20]. At 60° abduction and 120° flexion, the joint reaction forces measured 224 N, which is closest to the value reported to be conducive to healthy hip development. Since this position mimics the ‘M’ position assumed by the infants’ hips in baby-wearing, the authors concluded that baby-wearing is beneficial for normal hip development.

Another study which employed surface EMG and marker-based motion analysis to track muscle activity and movements around the hip joint in various seating devices, found

no difference between the Pavlik harness and baby-wearing [21]. The authors concluded that baby-wearing plays a crucial role in preventing DDH. On the other hand, muscle activity and hip position in the supine position in container-like devices, such as car seats and cradle-boards, can negatively impact hip development and predispose to DDH.

Swaddling (“Traditional” Versus “Hip-safe”)

Swaddling is a practice followed across many cultures through the millennia, in which the infant is wrapped in a cloth [22]. This practice has been shown to have several beneficial effects for the infant, including, better sleep patterns in the newborn by virtue of elimination of unnecessary movements, better thermoregulation, reduction in the incidence of sudden infant death syndrome (SIDS), faster recovery from painful stimuli and reduced crying [23, 24]. However, when done incorrectly, swaddling can be detrimental and cause overheating, increased respiratory infections when the chest is swaddled too tightly, sub-clinical Vitamin D deficiency, and an increased incidence of SIDS when swaddled infants are laid to sleep in the prone position [24]. From an orthopaedic viewpoint, the chief concern is the association between the technique of swaddling and occurrence of DDH [25–27].

Traditionally, the practice prevalent across many cultures has been to swaddle the baby tightly, with the hips in tight extension and adduction [6, 13] (Fig. 1). This posturing causes tightness in the iliopsoas, hamstrings and hip abductors, and, predisposes to hip dislocation. The tendency for dislocation is even higher in children with pre-existing hip dysplasia [28]. Cultures which practice “traditional” swaddling, with hips extended and adducted, have been shown to have a higher incidence of DDH [9, 26, 29]. Consequently, a history of improper swaddling is included as one of the indications for referral for selective ultrasound screening before 6 months of age by the American Academy of Pediatrics (AAP) [5].

Recognition of the detrimental effects of traditional swaddling has led to evolution of the concept of “hip-safe” swaddling [30]. Hip-safe swaddling implies swaddling with the infants’ lower limbs positioned in the so-called “froggy-leg attitude”, with the hips in slight flexion and abduction and the knees in slight flexion. Additionally, “hip-safe” swaddling should allow adequate space for the infants to move their hips and knees within the swaddle (Fig. 2). The International Hip Dysplasia Institute (IHDI) website describes in detail two different techniques of “hip-safe” swaddling: the diamond and square swaddle techniques [31].

Sleep sack swaddles are now commercially available. They consist of body-binders at the top which can be wrapped around the chest and fastened with Velcro straps,

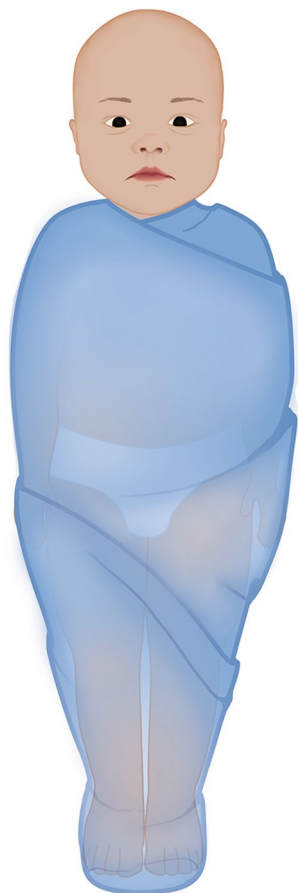


Fig. 1 Traditional hip swaddling with hips in extension-adduction and knees in extension



Fig. 2 “Hip-safe” swaddling allows unrestricted hip flexion-abduction and knee flexion

and, sleep sacks attached to the bottom which are roomy enough to allow free flexion-abduction of the hips and flexion of the knees. They eliminate loose blankets in the crib, since there is some concern that loose blankets may interfere with the baby's breathing and increase the risk of SIDS [32].

Baby-Wearing

Baby-wearing is the practice of carrying an infant or toddler by holding them close to the caregiver's torso with the lower limbs in an “M” position (hips flexed-abducted and knees flexed), either at the front or back or side. This has been achieved over centuries across several cultures by designing a simple swathe out of fabric, but now multiple designs of baby-carriers replete with fastening belts, cushions, and side-pockets are commercially available (Fig. 3).

A few disadvantages of baby-wearing, such as, increased incidence of backache and an adverse impact on gait of the care-givers have been noted [33]. Rare reports of infant asphyxiation during baby-wearing, due to pressing of the nose and mouth against the caregiver's body, have led to recommendations to keep the infant's face visible, with the nose and mouth always free [34, 35]. The advantages of baby-wearing include improved bonding between the caregiver and infant, decreased crying, better breast-feeding,



Fig. 3 Infant placed in baby-wearing device with lower limbs in ‘M’ position (hips flexed-abducted and knees flexed)

improved sleep patterns in the infant, and, freeing of hands of the caregiver for better multi-tasking [36–38].

From an orthopaedic viewpoint, baby-wearing is supposed to decrease the incidence of DDH. This is because, in baby-wearing, the infant's lower limbs are in the 'M' position with the knees in an attitude of flexion and the hips in flexion-abduction. For prevention of DDH, this is the safest position and mimics the position of the hips during treatment in a Pavlik harness or hip spica immobilization [21].

Scientific Evidence of the Association Between DDH and Post-natal Positioning

Epidemiological Evidence

The incidence of DDH shows wide geographic and cultural variation. A meta-analysis of 422 studies published in 2011 reported an incidence ranging from 0.6/1000 in Africa to 76.1/1000 in Native Americans [12]. Whereas part of this variation may be attributed to genetic factors, cultural differences in post-natal positioning is thought to be an important contributory factor. Evidence that post-natal positioning may be responsible for DDH comes in the form of a higher incidence of DDH seen in populations which practice restrictive immobilization of the lower limbs of their infants. Czeizel et al. [39] reported that out of 18,219 live births in Bekes County, Hungary, between 1970 and 1972, 523 infants came for treatment of developmental dysplasia of hip. Apart from genetic factors, the authors attributed this unusually high incidence of 28.7 per 1000 live births to unhealthy restrictive swaddling practices then prevalent in the studied population. Canadian Native Americans traditionally used cradle boards to immobilize and carry their infants. A radiographic study has shown that in cradle boards, hip abduction is restricted to 15° with no further abduction possible [6]. Salter, in 1968, studied the incidence of DDH in Canadian infants and reported a ten-fold higher incidence in infants in whom cradle-board immobilization was used (250/2032 live births, 12.3%), as against an incidence of 17/1347 live births (1.2%) in infants who were never immobilized on the cradle-board [27].

On the other hand, a lower incidence of DDH is seen in populations which practise hip-safe post-natal positioning. Graham et al. performed a retrospective review of 40,683 children under the age of 16 years treated at Beit CURE International Hospital, Malawi, and reported a 0% incidence of DDH [13]. The authors proposed that the low incidence of DDH in the local population was the result of the practice of back-carrying their infants in a position that is similar to that of the Pavlik harness [1]. The lower incidence of DDH in South China, among African Bantus, Thailand, Sri Lanka and North Korea is believed to be due the practice of

not swaddling their infants in the hip-extended position [10, 11]. The Inuit/Eskimos carry their infants in hooded jackets (Amauti), with the infants' hips abducted around their backs. A study of this population detected a low incidence of DDH (1.9 per 1000 live birth) [12].

A significant decrease in the incidence of DDH has been observed in populations which have adopted "hip-safe" techniques of infant positioning. In a study conducted on 2300 Navajo subjects, Rabin et al. noted a higher prevalence of DDH in the adult population as compared to the paediatric population. This change in prevalence of DDH was attributed to decreased use of the Navajo cradle board, in which the infant's hips were swaddled in extension and adduction, and wider usage of diapers which promoted hip abduction over the preceding 30–50 years [6].

A few studies, however, have failed to conclusively establish the protective effect of baby positioning against the occurrence of DDH. Hoaglund et al. studied the epidemiology of DDH in South China between 1960 and 1975, and reported an incidence of 0.005–0.009%, which was markedly lower than the incidence reported in Caucasians. *Prima facie*, this decreased incidence may appear to be due to the South Chinese tradition of carrying their infants in the "Hong Kong position" with hips flexed and abducted. However, when a sub-group analysis was performed within this population, DDH was found to occur with similar frequency in infants who were carried in "Hong Kong position" as in those who were not carried in that position [40]. In another study on 427 infants of the Cree-Ojibwa tribe with untreated DDH, 113 including 21 with frank dislocation, showed spontaneous improvement over a period of 1 year, even though the infants were continued to be swaddled on cradle-boards during this period [7]. A study from Saudi Arabia, in which 50 children with established diagnosis of DDH were compared with 414 children with normal hips, demonstrated no significant statistical difference between the incidence of restrictive swaddling in the two groups. Nevertheless, the authors expressed the possibility of swaddling affecting the outcomes of affected hips unfavourably and, therefore, recommended against the continuation of this practice [8].

Ultrasound Evidence

Ultrasound studies have followed normal hip development from the late stages of foetal development to the post-natal period [41]. The results of these studies suggest that, contrary to popular belief, the normally developing hip may be well-formed prior to birth. However, there might be a transient decrease of α -angle (acetabular roof angle) in the early post-natal period. Gardiner et al. proposed that greater mechanical stresses placed on the new-born hips due to forceful post-natal positioning in extension and adduction

contribute to the deterioration from mature hips in the third trimester to immature hips in the early post-natal period. In some cases, the deterioration may be severe enough to result in dysplastic hips [41].

Harcke et al. [42] used ultrasonography to study the impact of swaddling on hips of 30 infants with suspected or documented DDH. When tight swaddling with a blanket was applied, one unstable hip completely dislocated. On the other hand, no change of hip stability was observed when safe swaddling techniques were employed. The authors also studied hip position following application of commercially available swaddling products which appeared to mildly restrict leg motion. These products had an adverse effect on positions of three hips which were already under treatment with Pavlik harness. On the basis of these findings, the authors concluded that safe swaddling techniques which allow unrestricted hip motion should always be preferred over any form of swaddling which restricts hip motion [42].

Public Awareness

Awareness regarding the importance of hip-safe swaddling is unfortunately lacking. In a survey conducted by the senior authors (AA and RM) at our institute, which is a tertiary-care, urban based paediatric hospital catering to a high volume patient base, only 3/45 (6.6%) paediatricians, 4/100 (4%) caregivers and 0/219 (0%) nurses were aware of “hip safe swaddling” [43]. This study revealed the need to train nurses and paediatricians in hip-safe swaddling.

Campaigns aimed at creating public awareness regarding the benefits of “hip-safe” infant positioning have the potential to decrease the incidence of DDH. An educational campaign against the harmful effects of restrictive lower limb immobilisation was conducted in Kyoto, Japan, in 1973. A study conducted in 1976 showed that the incidence of DDH in Kyoto, after implementation of the programme, dropped from 52.9/1000 in 1971–1973 to 5.6/1000 in 1974–1976 [15]. Following its success, the programme was then implemented nation-wide which resulted in a decrease in the incidence of DDH in Japan from 3.5% before 1975 to less than 0.2% in 1984 [14]. Similar encouraging results were reported from Qatar, where implementation of a community programme creating awareness regarding the harmful effects of restrictive swaddling led to a drop in diagnosis rate of DDH in selective ultrasound screening from 20 to 6% [16].

Conclusion

Of the various risk factors known to be responsible for the causation of DDH, post-natal positioning is the only modifiable factor. It follows, therefore, that creating awareness

regarding the “hip-safe” positions for infant immobilisation can decrease the incidence of DDH. Evidence that “hip-safe” positioning is beneficial comes in the form of a higher incidence of DDH in populations which practice restrictive lower limb immobilisation and a lower incidence in cultures which have adopted “hip-safe” positioning. Additionally, populations which have shifted to “hip-safe” positioning following public awareness campaigns have demonstrated significant decrease in the incidence of DDH. It is time for professional organizations in India, such as, the Indian Academy of Pediatrics (IAP), Paediatric Orthopaedic Society of India (POSI), Federation of Obstetric and Gynaecological Societies of India (FOGSI) and others, to come together and develop a position statement and public awareness campaign on the importance of ‘hip-safe’ swaddling and proper techniques of baby-carrying in order to reduce the incidence of DDH in our country.

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Declarations

Conflicts of interest The authors declare that they have no conflict of interest, financial or otherwise, relevant to this study.

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Informed consent For this type of study informed consent is not required.

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