Post-Natal Positioning through Babywearing: What the Orthopaedic Surgeon Needs to Know

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Abstract: Babywearing is the practice of using a swathe of fabric or purpose-built carrier to hold an infant or toddler close to the caregiver's torso for multiple hours of the day. The child's legs are often positioned in an "M" shape, with hips and knees flexed and the hips abducted. There is increasing interest in the potential for babywearing to assist in hip development, as the "M" position assumed in most carriers is similar to the position achieved in harnesses/braces used in the treatment of developmental dysplasia of the hip (DDH). The association between low incidence of DDH in babywearing populations suggests this may play a role in optimal hip development. The purpose of this review is to present epidemiological, comparative, biomechanical, and imaging studies that investigate the potential impact of babywearing on hip development while outlining other benefits such as caretaker-infant responsiveness, attachment and bonding, and potential parental benefits such as decreased crying, improved breastfeeding, caregiver multi-tasking, as well as potential complications and impact on gait and posture for those supporting an infant.

Key Concepts:
- Babywearing involves using a swathe of fabric or purpose-built carrier to hold an infant or toddler close to the caregiver's torso for multiple hours of the day.
- Observational population studies demonstrate an association between babywearing and low incidence of DDH, although genetic factors may also play a role.
- Babywearing in an "M" position with hips flexed and abducted mimics the position obtained in a Pavlik harness and is theorized to promote hip development.
- Non-orthopaedic benefits of babywearing include stimulating caretaker-infant responsiveness, improving attachment and bonding, promoting language development, decreasing infant crying, supporting breastfeeding,

Introduction

Babywearing is the practice of using a swathe of fabric or purpose-built carrier to hold an infant or toddler close to the caregiver's torso, be it the front, back or side (Figure 1). The child is close enough to feel the parent's warmth, and hear their heartbeat, voice, and breathing. Often, the infant's legs are positioned in an "M" shape, with hips and knees flexed and the hips abducted. Babywearing has been used for thousands of years in

some cultures, keeping the child close, warm, calm, and allowing the caregiver's arms to be free for other work. Babywearing involves carrying the baby for multiple hours in the day by a parent or caregiver. It has also been trending in recent years, concurrent with parental interests in attachment parenting (promoting the attachment of parent and infant not only by maximal parental empathy and responsiveness but also by continuous bodily closeness and touch). Multiple carriers exist, ranging from a simple piece of fabric that is tied about the body to custom made carriers with extensive fastening clips, cushions, and pockets. Families are using baby carriers, and orthopaedic surgeons need to know the orthopaedic and non-orthopaedic benefits and potential complications of this form of post-natal positioning.

The etiology of DDH has not been fully elucidated but a combination of genetic, hormonal, and mechanical factors may play a role in its development. While associations with positive family history[1] and female sex[2] may be due to genetic and hormonal factors, the risks associated with first borns,[3] post-maturity birth,[2] birth weight >4 kg,[2,4] oligohydramnios,[5] breech position[4] in utero, and vaginal birth of breech babies all seem consistent with abnormal peri-natal mechanics. Post-natal positioning has also been implicated. In particular, swaddling and carrying practices that restrict hip and knee flexion are believed to increase the risk for DDH,[6] while the "M" position is hypothesized to be protective.[7]

The primary objective of this review is to provide comprehensive and up-to-date information on babywearing and its impact on hip position and development, focusing on reports of DDH incidence in cultures that practice babywearing as well as studies that utilize imaging and biomechanical models to investigate

Figure 1. *Contemporary babywearing with the hips in the "M" position*

hip position and anatomy during babywearing. The secondary objective is to contrast these findings with other forms of post-natal hip positioning and their associations with hip development. Practical information on non-orthopaedic benefits and potential complications are also provided.

Association Between Babywearing and DDH

A systematic review of 422 articles focusing on the epidemiology and demographics of DDH reported an incidence ranging from 0.06/1000 in Africa to 76.1/1000 in Native Americans.[8] The significant variability in incidence within these racial and geographic groups could be genetic but may also be influenced by cultural/ethnic post-natal positioning practices.

A retrospective review of medical records between 1960 and 1975 reported an incidence of 0.005-0.009% of DDH in Southern China, approximately 10 times less than that found in Caucasians.[10] In Southern China,

Table 1. Incidence of DDH by Infant Hip Position in Communities that Practice Babywearing

Authors	Study Population	Infant Hip Position	Incidence of DDH
Graham 2015[9]	Malawi, November 2002-September 2012	Back-carry infants for first 2-24 months in "M" hip position	0% (0/40683)
Hoaglund 1981[10]	Southern China, 1968-1974	Back-carry infants in "M" hip position (~50% of the population)	0.005-0.009%
Bower 1987[11]	Western Australia, 1981-1983	No direct measurement of baby-carrying; Aboriginal infants are known to spend a large proportion of their lives being carried with their hips abducted by mother or other family member	0.37% (Aboriginal) 0.66% (non-Aboriginal)
Roper 1976[14]	Bantu people, 35 years	Traditional Bantu infant carrying method, "M" hip position	0.0025% (1/40000)

infants are traditionally held in the "Hong Kong" position, on their mothers' backs with hips flexed and abducted. Of those with hip dislocations, 41% were carried in the "Hong Kong" position during the first 6 months of life compared to 49% in a control group without DDH.[10] During the first 2 years of life, 67% with DDH were held in the "Hong Kong" position compared to 54% in the control group. There was no difference in the number of hours of carrying between the DDH and control groups. The authors concluded that while the Hong Kong position could be beneficial, other factors such as genetics likely account for the rarity of DDH in Southern China.

A population-based study of children born in Western Australia in 1981 to 1983 showed low rates of DDH among infants born to Aboriginal mothers, with a rate of 3.7/1000 births in Aboriginal women compared to 6.6/1000 births in non-Aboriginal women.[11] The authors reported that Aboriginal infants spend a large proportion of their early lives being carried with their hips abducted, either by their mother or members of the extended family. This cultural practice was hypothesized to be the primary explanation for the differences in DDH incidence. However, this relationship with babywearing

was observational and speculative; there was no direct measurement of babywearing in either group.

Inuit living around the North Pole commonly carry their infants in a hood (amauti) inside their parkas.[12] This practice abducts the infant's hips by straddling the mother's back. Despite a genetic origin believed to be similar to Native Americans who have a high incidence of DDH, Inuit's practice back-carrying are reported to have a significantly lower incidence of DDH compared to Caucasians.[12,13] Of note, the original article that was cited documenting the incidence in this population could not be obtained and checked for accuracy.[13]

Several case series have commented on the low rates of DDH among African cultures. Many Central and Southern African populations traditionally back-carry their infants. Roper et al.[14] observed the rarity of DDH in the Bantu population; in an estimated total of 40,000 patients seen over 35 years, there was only one reported case of typical DDH. Due to the concurrent low incidence of osteoarthritis in the Bantu adults, Roper and colleagues believed genetics to be the greatest protective factor in this population.[14] Griffiths[15] and van Meerdervoort[16] also presented cases of infants from

**Table 2. Incidence of DDH by Infant Hip Position in
Communities that Practice Swaddling and Use Cradleboards**

Authors	Study Population	Infant Hip Position	Incidence of DDH
Ishida 1977[32]	Kyoto City, Japan, 1971-1976	Tight swaddling was used before a local campaign emphasized the importance of preventing DDH. In 1973, the educational program included recommendations to avoid prolonged extension of the hip and knee during early postnatal life.	5.3% in 1971–1973 versus 0.6% in 1974–1976
Yamamuro 1984[33]	Japan, 1975	Tight swaddling was used before a 1975 national Japanese campaign with recommendations to avoid prolonged extension of the hips and knees of infants during the early postnatal period	3.5% before 1975 campaign versus less than 0.2% after 1975 campaign
Mellbin 1962[42] and Getz 1955[43]	Sámi, indigenous people of Sápmi, the circumpolar areas Europe (Sweden, Norway, Finland, Kola Peninsula of Russia)	Cradleboard (gietka or komse) hollowed from a log tightly swaddling the lower extremities and allowed for minimal movement	2.5% (Mellbin) 4.0% (Getz)
Salter 1968[40]	Canadian Indian Tribes, 1963	Cradleboard (Tikonagan) with hips in extension and adduction	12.3% (250/2032 live births with cradleboard use) vs. 1.2% (17/1347 live births without cradleboard use)
Rabin 1965[41]	Navajos born 1910-1930 and 1955-1961	Cradleboards were traditionally used, with hips in extension and adduction. Diapers were introduced before 1955 leading to a decreased use of cradleboards	2.6% (1910-1930) versus 0.7% (1955-1961)

Central and Southern Africa with DDH; however, they suggested that back-carrying is an important preventative measure in addition to genetic factors.

To further investigate this hypothesis, a recent review and retrospective cohort examined the diagnosis and management of all infants seen at the Beit CURE International Hospital in Malawi and its mobile clinics, from November 2002 to September 2012. In a population of 40,683 children, Graham et al.[9] found no patients with a diagnosis of DDH. The majority of mothers in Malawi back-carry their infants for the first 2 to 24 months in the "M" position; the authors believed this was primarily responsible for the low incidence of DDH in Malawi.[9]

The low incidence of DDH in Africa (weighted average 0.06/1000) and the higher incidence of DDH among Blacks in the United States (weighted average 0.40/1000) is of interest.[8] Between 1977 and 1982, the incidence of DDH at a single institution in Louisiana was reported to be 1.5/1000 among White children and 0.46/1000 among Black children. A retrospective review at a single institution in Indiana assessed the race distribution of patients with DDH to the race distribution of live births.[12] They found that 4.0% of infants with DDH were Black, while Black babies made up 11.7% of the live births. In comparison, 80.8% of infants with DDH were White, while White babies made up 77.0% of live births. Overall, the incidence of DDH among Blacks in the United States is higher than in Africa but lower than for Whites in the United States. The authors believed the etiology of these differences to be multifactorial and related to both genetic heterogeneity (intermarriage of Blacks and Whites in the United States) and to cultural baby transporting practices. It was hypothesized that Black infants in North America are more likely to be transported in baby strollers and car seats, rather than carried with the hips in an abducted position.[12]

Hip Biomechanics in Babywearing

Recent studies on hip biomechanics suggest that babywearing is beneficial to hip development. A computational model of a 1-year-old infant's lower extremities was constructed with modeling software to investigate the relationship between babywearing positions and hip joint reaction forces.[17] The model was subjected to a range of hip flexions and abductions, while keeping external rotation fixed at 10 degrees. At 60 degrees of abduction and 120 degrees of flexion, the infant right hip model produced a joint reaction force of 244 N, closest to the value reported to be beneficial for healthy hip development and to the *in vivo* joint reaction forces known to be present with a standing leg raise.[17] The authors concluded that babywearing in the "M" position with hips abducted and flexed is conducive to healthy hip development.

In another study, lower-extremity muscle activity and hip position was measured in 20 healthy full-term infants positioned in a Pavlik harness, a rigid hip abduction brace, an inward-facing soft-structured baby carrier, a standard car seat, and held in arms.[18,19] Surface EMG was used to record muscle activity and marker-based motion capture was used to track lower extremity motion. The authors found no difference in hip flexion, abduction, external rotation, and lower limb muscle activity between the Pavlik harness and the baby carrier.[18,19] In contrast, having the infant in a car seat resulted in approximately half of mean adductor and quadriceps muscle activity compared to the Pavlik harness. The authors suggested that baby carriers could play a crucial role in preventing DDH and/or supplementing the treatment of DDH.[18,19]

Hip Ultrasound While Babywearing

Imaging has also been utilized to characterize hip position while babywearing. Fontecha et al. used ultrasound to assess whether three different baby-carriers ranging from a loose semi-flexed "M" position (original Baby Bjorn, BabyBjörn, Lanna, Sweden) to a moderate

"M" position (Baby Bjorn One, BabyBjörn, Lanna, Sweden) to a more extreme hyper-flexed "M" position (Manduca, Wickelkinder GmbH, Marburg, Germany) could influence the femoral head position (alpha angle and % acetabular coverage) while in the carriers.[20] Fifteen healthy infants aged 1.5 to 3.5 months underwent bilateral on-table static diagnostic ultrasounds, and were confirmed to have Graf 1 (normal) hips. Right hip static ultrasounds in the three baby-carriers were then obtained and no difference in alpha angle, acetabular coverage, or distance to the pubis was identified. The authors concluded the infants' hip maintains normal ultrasound parameters when placed in the tested baby-carriers, with the caveat that dysplastic hips may react differently. It should be noted that this was immediate testing, and the authors did not investigate the effects of long-term positioning in these carriers.

Other Post-Natal Positioning and Effects on Hip Development

In contrast to the "M" hip position, swaddling the legs in an extended and adducted position is a risk factor for DDH (Table 2). DDH is rare in cultures where swaddling is not used (Southern Chinese,[10] African Bantu,[14] Thailand,[21,22] North Korea,[23] Sri Lanka[24]). In contrast, communities with prevalent swaddling practices have higher incidences of DDH. In Saudi Arabia, studies have demonstrated that swaddling is an important factor in the etiology of DDH.[25,26] The high incidence of DDH in Arabic peoples in Western Galilee[27] and Iraqi immigrants in Israel[28] has been attributed to this practice. In Hungary,[29] swaddling was believed to account for the high incidence (28.7/1000) of DDH which is much greater than incidences in countries of Western Europe and North America. A retrospective cohort of 392 patients from a multicenter database in the United States reported that babies with a history of swaddling have a 2x greater odds of developing late-presenting DDH compared to babies who were not swaddled.[30] A systematic review cited 11 additional epidemiologic studies that have shown a strong correlation between incidence of DDH and the traditional use of swaddling for newborn infants.[31]

Public health campaigns educating patients on the problems associated with swaddling in extension have been utilized to reduce the incidence of DDH. In Kyoto, Japan, the incidence of DDH dropped from 52.9/1000 in 1971–1973 to 5.6/1000 in 1974–1976 after an educational campaign against tight lower extremity swaddling.[32] The results from Kyoto led to a national Japanese education and prevention program with similarly striking reductions in incidence of DDH: from 3.5% before 1975 to less than 0.2% following the national program.[33] In Turkey, the odds ratio of DDH in swaddled children compared to non-swaddled children has been reported to range from 2.9 to 6.1[34,35] and one study found that 98% of DDH patients were swaddled compared to 87.1% of non-DDH patients (p<0.05).[36] Despite efforts in Turkey to educate parents about the risks of tight swaddling of lower extremities, one institution reported that approximately 75% continued to swaddle their babies with legs extended.[37] In Qatar, the implementation of a community awareness program demonstrating the harmful effects of swaddling reduced the incidence of ultrasonographic dysplasia in children at high risk for DDH from 20% to 6%.[38]

Ultrasound has also been used to evaluate hip joint stability in infants who were swaddled by the traditional tight method, safe blanket techniques, and commercial devices.[39] Harcke et al. compared 16 infants in a Pavlik harness "treatment group" and 14 infants in a "non-treatment" group. They reported that tight swaddling restricts range of motion in comparison with range of motion allowed by safe (allowing hip flexion and abduction) swaddling methods.[39] Safe swaddling does not affect hip position; no stable or unstable hip exhibited an immediate position change in comparison with the initial sonogram. Lastly, they concluded that safe swaddling does not affect stable hips in a Pavlik harness but can affect unstable hips.[39]

Table 3: Reported Benefits and Risks of Babywearing

Benefits of Babywearing	Risks and Complications Associated with Babywearing
▪ Hip development (does not harm and may improve) ▪ Promotes caretaker-infant responsiveness, attachment, and bonding ▪ Language development ▪ Decreases infant crying ▪ Improves breastfeeding ▪ Convenient (allows for multi-tasking)	▪ Sudden infant death/asphyxia ▪ Falls/trauma ▪ Baby-carrier purpura ▪ Impact on caregiver energy expenditure and fatigue ▪ Impact on caregiver gait and posture, low back pain

Cradleboards have been used in some cultures for keeping children warm, still, away from hazards such as open fires, and for transportation. Similar to traditional swaddling, cradleboards typically restrict the legs in a static extended position. In Canada, the Cree of northern Quebec used cradleboards until 1.5 years of age.[40] This population was noted to have a high burden of DDH. In addition to the use of cradleboards, they were noted to have significant multidirectional ligamentous laxity of the hips, and femoral anteversion, with preferred W sitting.[40] Due to spontaneous normalization of some hips, the author hypothesized that much of the hip dysplasia was due to hip adduction forces caused by the cradleboards, and the hips normalized once these forces were discontinued. Similarly, a 10-fold increase in DDH (12.3% versus 1.2%) was reported in Canadian First Nations people from Ontario who used the cradleboard compared to those who did not.[41] In the United States, a study of approximately 2,300 Navajos[42] found hip dislocation to be more prevalent in adults than children (2.6% versus 0.7%, p<0.01). The authors postulated that the decreased dislocation in children was due to the transition from exclusive use of the Navajo cradleboard to the more frequent use of diapers, which had not traditionally been used, and may have resulted in comparatively greater hip abduction.

In Sámi, indigenous people of Sápmi, the circumpolar areas of Europe (Sweden, Norway, Finland, Kola Peninsula of Russia), the cradleboard (gietka or komse) was believed to account for the high incidence (24.6 to 40/1000) of DDH.[43,44] The gietka is a cradle hollowed from a log and where the child is placed with tight swaddling of the lower extremities and allowing only for minimal movement. This cradle was practical in the Sámi nomadic culture and lifestyle, allowing mothers to carry the cradle across their shoulders, or onto a reindeer's pack saddle.[43] As nomadic reindeer herding culture and lifestyles have changed, the prevalence of DDH in the Sámi has fallen.[45,46]

Non-Orthopaedic Benefits of Babywearing

In addition to the potential positive effects on hip development, babywearing has been shown to have several other benefits (Table 3). Babywearing allows frequent close physical contact between the caregiver and infant, thereby promoting caregiver responsiveness, secure attachment, and bonding.[47,48] Hours spent babywearing has also been positively correlated with secure attachment and negatively correlated with disorganized attachment in a cohort of infants born to adolescent mothers, a population that is at particularly high risk of developing insecure attachments and attachment disorders into adulthood.[49,50] Babywearing may also stimulate infant language development[51] while decreasing infant crying. In a randomized control trial, infants exposed to increased carrying throughout the day

cried 43% less than infants in the control group at 6 weeks.[52] Whilst babywearing, it is possible to position the infant to facilitate breastfeeding. Baby wearing increases the likelihood of responsive breastfeeding, feeding that is initiated in response to an infant's early hunger cues. Mothers who self-reported responsive feeding were more likely to exclusively breastfeed for the first 6 months and breastfeed more frequently throughout the day.[53] Practically speaking, babywearing also allows caregivers to engage in day-to-day activities while staying in close proximity to their infants. Caregivers can walk and multi-task, all while the infant remains close-by. Additionally, babywearing is thought to have a positive impact on maternal emotional well-being.

Risks and Complications of Babywearing

Suffocation has been reported while babies have been positioned in carriers.[54,55] Poor positioning in a sling or carrier, such that the infant's face is covered by fabric and the nose and mouth are pressed against the adult's body can increase the risk of asphyxiation.[56] Parents should be educated on proper babywearing, with infant's face and head visible at all times, nose and mouth free, and avoidance of the flexed chin-on-chest position. Falls and trauma to infants in carriers have also been reported.[57,58,59] Modes of injury included: cloth tearing, zippers coming undone or separating, hooks or fastening rings breaking, infants falling through leg openings, straps breaking, stitching unraveling, clasps or brackets breaking, and parents falling while carrying their child.

Rumpel-Leede phenomenon associated with baby carriers has also been described in the literature.[60] This phenomenon is characterized by petechiae and purpura localized to the lower extremities due to tourniquet-like forces from the cinching of the baby carrier tightly around the extremities. "Baby carrier purpura" is benign and lesions spontaneously resolve in a few weeks.

Babywearing increases caloric output[61] and can also alter gait and walking speed.[62,63] Carrying an infant in arms without the use of a sling has been shown to increase the mechanical load placed on the knee and hip joints in the frontal plane; however, babywearing with an anteriorly-worn carrier (with the infant facing the caregiver) was shown to more closely resemble unloaded walking.[64] Finally, infant carrying can also alter posture and the biomechanical alignment of the mother's trunk, which may constitute a potential risk factor for development of musculoskeletal pain.[69, 70 67–71,72] In caregivers with lumbar pain, the authors recommended lowering the wearing height of the baby carrier to pelvic level so that the external load could be transferred to the lower extremities.[72] (Table 3).

Conclusion

This review presents comprehensive evidence on the association between babywearing and improved hip development, as well evidence demonstrating diminished hip development (dysplasia) with alternate post-natal positioning (swaddling and cradleboards). Incidence of DDH is low amongst people who practice babywearing, including Southern China, Aboriginal people of Western Australia, Central and Southern Africa, Malawi, and the Inuit of the circumpolar north. Incidence of hip dysplasia is higher in American Indians and Sámi populations where cradleboards have traditionally been used. Granted, it is difficult to parse out the genetic versus environmental contributory factors. Biomechanical studies demonstrate that babywearing in the "M" position provides a healthy hip position, with similar positioning and muscle activation as achieved in a Pavlik harness. In addition to potentially promoting healthy hip development, babywearing stimulates caretaker-infant responsiveness, improves attachment and bonding, promotes language development, decreases infant crying, supports breastfeeding, and allows for caregiver multi-tasking. Caregivers must be aware of the rare but important risks of babywearing including asphyxia, falls/trauma, and baby-carrier purpura, all of which most commonly occur due to improper use or positioning.

Acknowledgements

References

1. Stevenson DA, Mineau G, Kerber RA, Viskochil DH, Schaefer C, Roach JW. Familial predisposition to developmental dysplasia of the hip. *J Pediatr Orthop*. Published online 2009. doi:10.1097/BPO.0b013e3181aa586b

2. Woodacre T, Ball T, Cox P. Epidemiology of developmental dysplasia of the hip within the UK: refining the risk factors. *J Child Orthop*. Published online 2016. doi:10.1007/s11832-016-0798-5

3. Barr L V., Rehm A. Should all twins and multiple births undergo ultrasound examination for developmental dysplasia of the hip?: A retrospective study of 990 multiple births. *J Bone Jt Surg - Ser B*. Published online 2013. doi:10.1302/0301-620X.95B1.29927

4. Bache CE, Clegg J, Herron M. Risk factors for developmental dysplasia of the hip: Ultrasonographic findings in the neonatal period. *J Pediatr Orthop Part B*. 2002;11(3):212-218. doi:10.1097/01202412-200207000-00004

5. Manoukian D, Rehm A. Oligohydramnios: Should it be considered a risk factor for developmental dysplasia of the hip? *J Pediatr Orthop Part B*. 2019;28(5):442-445. doi:10.1097/BPB.0000000000000624

6. Yamamuro T, Ishida K. Recent advances in the prevention, early diagnosis, and treatment of congenital dislocation of the hip in Japan. *Clin Orthop Relat Res*. Published online 1984. doi:10.1097/00003086-198404000-00005

7. Graham SM, Manara J, Chokotho L, Harrison WJ. Back-carrying Infants to Prevent Developmental Hip Dysplasia and its Sequelae. *J Pediatr Orthop*. 2015;35(1):57-61. doi:10.1097/BPO.0000000000000234

8. Loder RT, Skopelja EN. The Epidemiology and Demographics of Hip Dysplasia. *ISRN Orthop*. Published online 2011. doi:10.5402/2011/238607

9. Graham SM, Manara J, Chokotho L, Harrison WJ. Back-carrying infants to prevent developmental hip dysplasia and its sequelae: Is a new public health initiative needed? *J Pediatr Orthop*. Published online 2015. doi:10.1097/BPO.0000000000000234

10. Hoaglund FT, Kalamchi A, Poon R, Chow SP, Yau ACMC. Congenital hip dislocation and dysplasia in southern Chinese. *Int Orthop*. Published online 1981. doi:10.1007/BF00266064

11. Bower C, Stanley FJ, Kricker A. Congenital dislocation of the hip in Western Australia. A comparison of neonatally and postneonatally diagnosed cases. *Clin Orthop Relat Res*. Published online 1987. doi:10.1097/00003086-198711000-00006

12. Loder RT, Shafer C. The demographics of developmental hip dysplasia in the Midwestern United States (Indiana). *J Child Orthop*. Published online 2015. doi:10.1007/s11832-015-0636-1

13. Society for Applied Anthropology in Manitoba. Summary of SAAM presentations. *Anthr Pr*. 2001;10.

14. Roper A. Hip dysplasia in the Arican Bantu. *J Bone Jt Surg - Ser B*. Published online 1976. doi:10.1302/0301-620x.58b2.932075

15. Griffiths JC. Dislocated hip in East African infants and children. *Postgrad Med J*. Published online 1970. doi:10.1136/pgmj.46.532.86

16. Pompe van Meerdervoort HF. Congenital dislocation of the hip in black patients. *South African Med J*. Published online 1974.

17. Girish G. Computational Investigation of the Biomechanics of Babywearing in Regards to Developmental Dysplasia of the Hip. *ProQuest Diss Theses*. Published online 2017:68.

http://ezproxy.library.unlv.edu/login?url=https://search.proquest.com/docview/2035548385?accountid=3611%0Ahttp://unlv-primo.hosted.exlibrisgroup.com/openurl/01UNLV/01UNLV_SP??url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&genre=disserta

18. Siddicky SF, Tackett SA, Buchele L, Rabenhorst B, Mannen EM. INFANT HIP POSITION AND LOWER EXTREMITY MUSCLE ACTIVITY IN AN INWARD FACING BABYCARRIER AND THE PAVLIK HARNESS. Published online 2019.

19. Siddicky SF, Tackett SA, Buchele L, Rabenhorst B, Mannen EM. Lower extremity hip position and muscle activity during babywearing in soft structured baby carriers : Implications for developmental dysplasia of the hip. 2019;(C):4200.

20. Fontecha CG, Coma Muñoz A, Catala Muñoz A. Evaluation by ultrasound of the hips of babies carried in baby carriers. *Rev Esp Cir Ortop Traumatol*. 2019;63(4):289-294. doi:10.1016/j.recot.2019.02.002

21. Limpaphayom M, Bhongsvej S, Chitinanda SP. Orthopedic problems in the newborn. *J Med Assoc Thailand= Chotmaihet thangphaet*. 1975;58(7):363-367.

22. Limpaphayom M, Jeeravipoolvarn P, Chomcharn U. Congenital hip dysplasia in Thai children. *J Med Assoc Thailand= Chotmaihet thangphaet*. 1978;61(10):565.

23. JANECEK M. [Congenital hip dislocation in children in Northern Korea]. *Acta Chir Orthop Traumatol Cech*. 1956;23(1):2—5. http://europepmc.org/abstract/MED/13312918

24. Corea JR. Is congenital dislocation of the hip rare in Sri Lanka? *Ceylon Med J*. Published online 1992.

25. Abu-Nawarig M. Congenital dysplasia of hip in Eastern Province of Saudi Arabia. *Orthop Rev*. Published online 1981.

26. Kremli MK, Alshahid AH, Khoshhal KI, Zamzam MM. The pattern of developmental dysplasia of the hip. *Saudi Med J*. Published online 2003.

27. Alkalay I, Shmuel J. Detection and treatment of congenital dislocation of the hip in "babies at risk" in Western Galillee. *Br J Clin Pract*. Published online 1988.

28. Bloch A. The Kurdistani cradle story. A modern analysis of this centuries-old infant swaddling practice. *Clin Pediatr (Phila)*. Published online 1966. doi:10.1177/000992286600501012

29. Czeizel A, Szentpetery J, Kellermann M. Incidence of congenital dislocation of the hip in Hungary. *Br J Prev Soc Med*. Published online 1974. doi:10.1136/jech.28.4.265

30. Mulpuri K, Schaeffer EK, Andrade J, et al. What Risk Factors and Characteristics Are Associated With Late-presenting Dislocations of the Hip in Infants? *Clin Orthop Relat Res*. Published online 2016. doi:10.1007/s11999-015-4668-0

31. Van Sleuwen BE, Engelberts AC, Boere-Boonekamp MM, Kuis W, Schulpen TWJ, L'Hoir MP. Swaddling: A systematic review. *Pediatrics*. Published online 2007. doi:10.1542/peds.2006-2083

32. Ishida K. Prevention of the development of the typical dislocation of the hip. *Clin Orthop Relat Res*. Published online 1977. doi:10.1097/00003086-197707000-00028

33. Yamamuro T, Ishida K. Recent advances in the prevention, early diagnosis, and treatment of congenital dislocation of the hip in Japan. *Clin Orthop Relat Res*. 1984;(184):34-40. Accessed October 20, 2017. http://www.ncbi.nlm.nih.gov/pubmed/6705362

34. Akman A, Korkmaz A, Aksoy MC, Yazici M, Yurdakök M, Tekinalp G. Evaluation of risk factors in developmental dysplasia of the hip: Results of infantile hip ultrasonography. *Turk J Pediatr*. Published online 2007.

35. Ömeroğlu H, Akceylan A, Köse N. Associations between risk factors and developmental dysplasia of the hip and ultrasonographic hip type: A retrospective case control study. *J Child Orthop*. Published online 2019. doi:10.1302/1863-2548.13.180174

36. Kutlu A, Memik R, Mutlu M, Kutlu R, Arslan A. Congenital dislocation of the hip and its relation to swaddling used in Turkey. *J Pediatr Orthop*. Published online 1992. doi:10.1097/01241398-199209000-00006

37. Ceylan MF, Güner S, Gökalp MA, et al. Problems encountered in screening study with ultrasound for early diagnosis of developmental dysplasia of hip in eastern region of Turkey. *East J Med*. Published online 2018. doi:10.5505/ejm.2018.32932

38. Chaarani MW, Al Mahmeid MS, Salman AM. Developmental Dysplasia of the Hip before and after increasing community awareness of the harmful effects of swaddling. *Qatar Med J*. Published online 2002. doi:10.5339/qmj.2002.1.17

39. Harcke HT, Karatas AF, Cummings S, Bowen JR. Sonographic Assessment of Hip Swaddling Techniques in Infants with and Without DDH. *J Pediatr Orthop*. Published online 2016. doi:10.1097/BPO.0000000000000446

40. Ghibely A. [Hip dislocation in Indians of Quebec]. *Acta Orthop Belg*. Published online 1990.

41. Salter RB. Etiology, pathogenesis and possible prevention of congenital dislocation of the hip. *Can Med Assoc J*. Published online 1968.

42. Rabin DL, Barnett CR, Arnold WD, Freiberger RH, Brooks G. UNTREATED CONGENITAL HIP DISEASE. *Am J Public Heal Nations Heal*. Published online 1965. doi:10.2105/ajph.55.suppl_2.i3

43. MELLBIN T. The children of Swedish nomad Lapps. A study of their health, growth and development. *Acta Paediatr Suppl*. Published online 1962. doi:10.1111/j.1651-2227.1962.tb06553.x

44. Getz B. The hip joint in Lapps and its bearing on the problem of congenital dislocation. *Acta Orthop Scand Suppl*. 1955;18:1.

45. Eriksson AW, Lehmann W SN. Genetic studies on circumpolar populations. In: *The Human Biology of Circumpolar Populations*. ; 1980:81-168.

46. Holck P. The occurrence of hip joint dislocation in early Lappic populations of Norway. *Int J Osteoarchaeol*. Published online 1991. doi:10.1002/oa.1390010310

47. Anisfeld E, Casper V, Nozyce M, Cunningham N. Does Infant Carrying Promote Attachment? An Experimental Study of the Effects of Increased Physical Contact on the Development of Attachment. *Child Dev*. Published online 1990. doi:10.1111/j.1467-8624.1990.tb02888.x

48. Little EE, Legare CH, Carver LJ. Culture, carrying, and communication: Beliefs and behavior associated with babywearing. *Infant Behav Dev*. Published online 2019. doi:10.1016/j.infbeh.2019.04.002

49. Williams LR, Turner PR. Infant Carrying as a Tool to Promote Secure Attachments in Young Mothers: Comparing Intervention and Control Infants during the Still-Face Paradigm. *Infant Behav Dev*. Published online 2020. doi:10.1016/j.infbeh.2019.101413

50. Rankin Williams L, Turner PR. Experiences with "Babywearing": Trendy parenting gear or a developmentally attuned parenting tool? *Child Youth Serv Rev*. Published online 2020. doi:10.1016/j.childyouth.2020.104918

51. Mireault GC, Rainville BS, Laughlin B. Push or Carry? Pragmatic Opportunities for Language Development in Strollers versus Backpacks. *Infancy*. Published online 2018. doi:10.1111/infa.12238

52. Hunziker UA, Barr RG. Increased carrying reduces infant crying: A randomized controlled trial. *Pediatrics*. Published online 1986.

53. Little EE, Legare CH, Carver LJ. Mother–infant physical contact predicts responsive feeding among U.S. breastfeeding mothers. *Nutrients*. Published online 2018. doi:10.3390/nu10091251

54. Bergounioux J, Madre C, Crucis-Armengaud A, et al. Sudden deaths in adult-worn baby carriers: 19 cases *Eur J Pediatr*. Published online 2015. doi:10.1007/s00431-015-2593-6

55. Madre C, Rambaud C, Avran D, Michot C, Sachs P, Dauger S. Infant deaths in slings. *Eur J Pediatr*. Published online 2014. doi:10.1007/s00431-013-2238-6

56. Batra EK, Midgett JD, Moon RY. Hazards associated with sitting and carrying devices for children two years and younger. *J Pediatr*. Published online 2015. doi:10.1016/j.jpeds.2015.03.044

57. Claudet I, Gurrera E, Honorat R, Rekhroukh H, Casasoprana A, Grouteau E. Accidents domestiques par chute avant l'âge de la marche. *Arch Pediatr*. 2013;20(5):484-491. doi:10.1016/j.arcped.2013.02.071

58. Gaw CE, Chounthirath T, Smith GA. Nursery product-related injuries treated in United States emergency departments. *Pediatrics*. 2017;139(4). doi:10.1542/peds.2016-2503

59. Frisbee SJ, Hennes H. Adult-worn child carriers: A potential risk for injury. *Inj Prev*. Published online 2000. doi:10.1136/ip.6.1.56

60. Nguyen TA, Garcia D, Wang AS, Friedlander SF, Krakowski AC. Rumpel-Leede phenomenon associated with tourniquet-like forces of baby carriers in otherwise healthy infants: Baby carrier purpura. *JAMA Dermatology*. Published online 2016. doi:10.1001/jamadermatol.2015.6270

61. Wall-Scheffler CM, Geiger K, Steudel-Numbers KL. Infant carrying: The role of increased locomotory costs in early tool development. *Am J Phys Anthropol*. Published online 2007. doi:10.1002/ajpa.20603

62. Brown MB, Digby-Bowl CJ, Todd SD. Assessing Infant Carriage Systems: Ground Reaction Force Implications for Gait of the Caregiver. *Hum Factors*. Published online 2018. doi:10.1177/0018720817744661

63. Sosanya OM, Wall-Scheffler CM, O.M. S, C.M. W-S. Baby carrying positions change walking speed. *Am J Phys Anthropol*. Published online 2018.

64. Williams L, Standifird T, Madsen M. Effects of infant transportation on lower extremity joint moments: Baby carrier versus carrying in-arms. *Gait Posture*. Published online 2019. doi:10.1016/j.gaitpost.2019.02.004

65. Evanna Singh. THE EFFECTS OF VARIOUS METHODS OF INFANT CARRYING ON THE HUMAN BODY AND LOCOMOTION. Published online 2009.

66. Schmid S, Stauffer M, Jäger J, List R, Lorenzetti S. Sling-based infant carrying affects lumbar and thoracic spine neuromechanics during standing and walking. *Gait Posture*. Published online 2019. doi:10.1016/j.gaitpost.2018.10.013

67. Cho S, Kim C. Ergonomic Differences between Baby Carriers by Certain Wearing Positions. *J Int Acad Phys Ther Res*. Published online 2019. doi:10.20540/jiaptr.2019.10.2.1774

68. Izumi A, Matsubara S. Biomechanical effects of baby sling in static posture. *Gait Posture*. Published online 2019. doi:10.1016/j.gaitpost.2019.07.310

69. Lee H, Hong KH. Evaluation of Pressure Distribution, Muscle Activity, and Subjective Comfort according to the Baby Carrier Type. *J fash bus*. Published online 2017.

70. Lee H, Hong KH. Evaluation of Muscle Fatigue and Subjective Fatigue depending on the Hip Seat and Waist Support Band of Baby Carrier. 한국의류산업학회지. Published online 2017. doi:10.5805/SFTI.2017.19.4.504

71. Wu CY, Huang HR, Wang MJ. Baby carriers: a comparison of traditional sling and front-worn, rear-facing harness carriers. *Ergonomics*. Published online 2017. doi:10.1080/00140139.2016.1168871

72. Park H-K, Shin H-K, Nam K-S. Investigation of wearing methods of a baby carrier on muscle activation during trunk flexion-extension in healthy women. *Phys Ther Rehabil Sci*. Published online 2020. doi:10.14474/ptrs.2020.9.1.36