Back-carrying Infants to Prevent Developmental Hip Dysplasia and its Sequelae: Is a New Public Health Initiative Needed?

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Background: Developmental dysplasia of the hip (DDH) is rarely encountered in the native sub-Saharan African population. We present a retrospective review of the incidence of symptomatic DDH in Malawi and a systematic review of the role of back-carrying as a potential influence of prevalence in this population group.

Methods: We retrospectively reviewed the diagnosis and management of all infants seen at the Beit CURE International Hospital, Malawi and its mobile clinics, from November 2002 to September 2012. In addition, methodical review of the literature using the Preferred Reporting Items for Systematic Reviews and Meta-analyses checklist and algorithm was performed.

Results: A total of 40,683 children aged less than 16 years were managed at our institute over a 10-year period, of which 9842 children underwent surgery. No infant presented with, or underwent surgical intervention, for symptomatic DDH.

Conclusions: The majority of mothers in Malawi back-carry their infants during the first 2 to 24 months of life, in a position that is similar to that of the Pavlik harness. We believe this to be the prime reason for the low incidence of DDH in the country. In addition, there is established evidence indicating that swaddling, the opposite position to back-carrying, causes an increase in the incidence of DDH. There is a need for the establishment of a large clinical trial into back-carrying and prevention of DDH in non-African population groups.

Level of Evidence: Level II.

Key Words: back-carrying, development hip dyplasia, osteoarthritis

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Developmental dysplasia of the hip (DDH) is a multifactoral disease that can vary from transient neonatal hip instability to hip dislocation. The prevalence of neonatal hip instability is approximately 20 per 1000 live births, and for established dislocation in an unscreened population is 1.3 per 1000 births.[1,2] DDH has clear established risk factors, including breech presentation, female sex, first born, family history, oligohydramnios, and maternal hyperthyroidism. However, in numerous cases the cause is not known.[1,3,4]

Within high-income countries, the management of DDH in the first instance is commonly in a Pavlik harness, that places the child's hip in a position of hip flexion and abduction, assuming the disease is recognized within the first 6 months.[1–3,5] Studies have shown this method of treatment to be highly successful, and by 18 months of age many children with DDH will go on to have an acetabular index on ultrasound scan (USS) that is indistinguishable from that of a child who has not had DDH.[5] Approximately 80% to 95% of children diagnosed early and treated in a harness will not require further intervention.[5,6]

If the diagnosis of DDH is not made, or is delayed, this can have significant effects on the future skeletal development of a child and also increase the likelihood of developing adult hip osteoarthritis.[2,3,7] In Norway, a total of 84,871 primary total hip arthroplasties were reported to the Norwegian Arthroplasty Registry for the period from 1987 to 2003. Of these, 6347 (7.5%) were performed because of sequelae of DDH, a further 788 (0.9%) were because of DDH with dislocation, and 59,774 (71.0%) because of primary osteoarthritis.[7]

Anecdotal evidence from experienced surgeons working in Central and Southern Africa has reported very few cases of DDH within these regions, although no accurate published data are currently available.[8–11]

The Beit CURE International Hospital in Blantyre, Malawi, is the only pediatric orthopaedic hospital in the country, serving a population of approximately 7 million children as well as offering services in the city of Blantyre; the hospital also operates mobile clinics that serve the rest of the country and parts of neighboring Mozambique. Our study group's observation of low rates of DDH in

children being treated at Beit CURE International Hospital prompted this study.

It is not fully understood why DDH is rarely encountered within these regions. There has been debate regarding whether this represents a genetic difference or is due to the method by which mothers carry their children during infancy.[8–11] It is a common practice for mothers to carry infants on their backs, in a position that mimics the Pavlik harness—the traditional first-line method of treating DDH in many high-income countries. (Fig. 1) We performed a systematic review of the literature examining the current evidence suggesting that back-carrying may contribute to the low incidence of DDH in African populations, and undertook a retrospective review of the occurrence of symptomatic DDH in Malawi, a country in central Africa where backing-carrying infants is common.

FIGURE 1. An example of how mothers back-carry their infants in Malawi–author with child.

METHODOLOGY

Systematic Review

A methodical review of the literature using the Preferred Reporting Items for Systematic Reviews and Meta-analyses checklist and algorithm was performed We searched for all in vitro and in vivo animal and human randomized controlled trials, cohort studies, case series, case reports, and review papers that explored the subject of positional carrying of an infant and DDH. No age restriction was applied. Potentially eligible trials were identified by searching electronic databases looking at the role of position of carrying an infant or swaddling and DDH using PubMed, Cochrane, MEDLINE/OVID, EMBASE, NHS Evidence, and Google scholar. A combination of subject headings and text words were used. Searches were not restricted by language or publication status. To identify ongoing or unpublished trials we searched the WHO International Clinical Trials Registry Platform. We also examined the reference lists of eligible trials and reviews. Two authors (S.G. and J.M.) independently screened the search output to identify records of potentially eligible studies and reviews, the full texts of which were retrieved and assessed for inclusion.

Studies were included if they reported in vivo and/or in vitro experimental findings regarding the effect of positional carrying of an infant and its effect on DDH. We contacted trial authors to obtain any missing outcome data. Studies were excluded if they did not include an analysis or discuss the effects of positional carrying on DDH.

Retrospective Review of Developmental Hip Dysplasia in Malawi

We undertook a retrospective review of all patients, under the age of 16, managed at the Beit CURE International Hospital and its mobile clinics over a 10-year period from September 2002 to September 2012. Given that this is the only hospital in Malawi that provides elective pediatric orthopaedic care, it is reasonable to assume that all children whose parents sought medical advice would have been seen at the hospital or in its mobile clinics.

We searched the hospital electronic database which registers all admissions. All the hospital diagnosis codes were reviewed and those patients who were coded as having hip dislocation, dysplasia or DDH had their notes and x-rays reviewed retrospectively.

RESULTS

A total of 40,683 infants were assessed in clinics over the 10-year period and 9842 infants underwent surgery for elective pediatric orthopaedic complaints. Twenty-three infants were coded as having potential hip

dysplasia. Following review of these patients' x-rays and notes, none of these had a diagnosis of idiopathic DDH.

In addition, we analyzed the data from the Malawi National Joint registry, to consider the frequency of symptomatic osteoarthritis in the hip relative to that in the knee. We made comparison of the ratio of primary hip to knee replacements, performed in 2012, for osteoarthritis in Malawian patients, and compared this with data from the British National Joint Registry. In Malawi, the ratio was 28 hips:96 knees, whereas in the UK it was 93:97, suggesting a much lower incidence of symptomatic adult hip osteoarthritis in the Malawians.[12,13]

DISCUSSION

Systematic Review: Back-Carrying and DDH

The search process identified 4454 studies of which 38 were initially selected for review in this paper. Nine papers analyzing the effects of swaddling on DDH were included. Ten papers analyzing the effect of back-carrying were included. There was cross-over in some of these papers. The evidence in humans is limited to date, mainly case reports of specific cases and we found no evidence on rates of DDH in Malawi or Central Southern Africa specifically. There were 8 papers that specifically used animal models comparing the effects on the hip of different positions on the development of hip dysplasia.

Back-carrying is universally used throughout Central and Southern Africa, as the sole method of transporting infants. It is very rare for buggies and prams to be used, for cultural, environmental, and economic reasons. It is common for parents or guardians to start back-carrying at 2 to 6 weeks and continue until the infant is around 18 to 24 months old. Infants are usually carried in this position for a number of hours during the day.

The acetabulum is at its most shallow at birth and this is when it is at its most unstable and susceptible to extrinsic forces.[14] In animal studies, splinting the hip joint in fixed extension during the first few weeks of life, results in the development of acetabular dysplasia that is reversible if held in flexion, a similar position to back-carrying.[14,15]

Roper et al,[10] in 1976, first reflected that back-carrying infants, with the hips abducted and flexed, may explain the low incidence of DDH in the Bantu population of Africa.[5] However, Roper and colleagues rejected this hypothesis, suggesting a genetic component was the main influence. This was because Roper and colleagues believed that primary osteoarthritis of the hip also did not occur in the Bantu population. However, although the incidence of hip osteoarthritis is low in the Bantu population, it does occur. In addition, it is possible that the low incidence of adult hip osteoarthritis in the Bantu population may well be related to the fact infants do not suffer from symptomatic DDH, due to back-carrying, and all acetabuli are well-moulded by back-carrying.

Roper and colleagues, Griffiths, and Pompe van Meerdervoort all presented a number of infants from Central or Southern Africa with DDH. However, all these patients either had an additional underlying congenital disorder and therefore could not be described as "typical" cases of DDH, or were not back-carried, or were swaddled during the first few months.[8–10] Unlike Roper and colleagues, Griffiths, and Pompe van Meerdervoort considered back-carrying to be an important prophylactic measure in preventing DDH.[8,9]

A more recent study in Southern China suggested that the low reported incidence of DDH in this region may be to due to the "Hong Kong" position in which infants are commonly carried. Like back-carrying in Africa, the "Hong Kong" position results in infants' hips being abducted and flexed, although in this case the infant is carried on the front rather than the back.[16]

There is established evidence that indicates that swaddling, whereby the child is tightly wrapped in a blanket with the hips adducted and extended, that is, the opposite to back-carrying, causes an increase in the incidence of DDH.[3,17–22] A program in Japan, where DDH rates were high, which aimed to avoid prolonged swaddling, was shown to reduce rates of DDH by up to 5 times, with national rates falling from 1.1% to 3.5% pre-1965 to $<0.2\%$ after the introduction of this campaign.[18]

Burke et al[23] examined the rates of DDH in Africans and African-Americans between 1977 and 1982. Previously it was thought the black population had relative immunity from developing DDH, because of genetic influences,[8–11] Burke et al[23] confirmed that rates of dislocation in African-Americans were statistically higher compared with the African population. The authors highlighted cultural and environment differences between the 2 groups as the main reason for the differences, one of which was back-carrying.[23]

In Kenya, surgeons have reported experiencing more cases of DDH in black Africans as the urban culture of the country changes and more infants are carried in prams rather than by traditional methods of back-carrying.[24] However, no clinical results are currently available.

DDH in Malawi

To our knowledge, this is the first report of national data regarding symptomatic DDH in Malawi, or any other country in Southern or Central Africa. We believe that a major contributing factor to these low rates is that Malawian parents back-carry their infants.

Application of the Pavlik harness for treatment of DDH has resulted in the successful reduction of up to 99% of dislocated hips.[25–29] All investigators have suggested that the earlier the treatment is started, the better results can be achieved.[26,30,31] In high-income countries treatment with the Pavlik harness begins at or after around 2 weeks and treatment normally lasts for approximately 2 to 3 months. After which point if the infant is still symptomatic, treatment is deemed a failure. In Malawi back-carrying is initiated from 2 weeks, sometimes even earlier, and continued until of the infant is 24 months or even older. Therefore, any infants that may have DDH are potentially being treated from a very young age, in a position that mimics a Pavlik Harness.

Our study group acknowledges that there are numerous factors that contribute to the potential development of hip dysplasia, with genetics likely to be a significant factor. Although there is ongoing research into potential genes linked to the development of DDH, to date no definite gene has been isolated.[32–35] There is a large variation in the reported incidence of DDH according to geographic location. For example, there is high reported incidence in countries such as Japan, Turkey, and other Mediterranean countries and low incidence reported in Southern China, Hong Kong, and Africa.[1,32] Suggesting either a genetic or environmental component, or both.

We acknowledge the fact that some infants may not have access to our facility or its mobile clinics and this could have affected our results. A further limitation is the lack of long-term follow-up on the study population, although children retained access to the service up to the age of 16 years. However, we are not suggesting that DDH does not occur within this population group, but that it does not become a symptomatic problem—or at most it is an exceedingly rare one.

CONCLUSIONS

The implications of our hypothesis are considerable for high-income countries, as by promoting a cultural shift to back-carrying, it may also be possible to eliminate or significantly reduce symptomatic DDH in these countries, without the cost and inconvenience of screening and interventions. It may also be possible to promote a significant reduction in adult hip osteoarthritis requiring hip replacement. Currently, there is no in vivo evidence to confirm our hypothesis, but we propose a randomized controlled trial to be conducted in a high-income country, examining the impact of back-carrying on the development of symptomatic DDH. If the incidence of DDH can be reduced from 20 per 1000 to zero per 1000 by back-carrying, then a randomized prospective controlled trial with 400 cases in each group should have an 80% chance of demonstrating this difference. Furthermore, a smaller randomized prospective study examining the effect of back-carrying on the hip Graf angle or acetabular index on USS would demonstrate the impact of back-carrying on the development of "normal" hips. An additional study that will help to further develop the understanding of this complex issue would be to perform USS on a population of children in UK and in Malawi, to examine if the acetabular development is the same in children in Malawi as in infants in the United Kingdom.

If a carrying position of infants during their early months of development can reduce the incidence of DDH, then a public health initiative promoting back-carrying could have significant world health and financial implications in the future management of DDH and also have potentially huge effects on the timing and severity of development of adult hip arthritis.

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