Ultrasound evaluation of healthy infant hips in the Pavlik harness and commercial baby carriers

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INTRODUCTION: Developmental dysplasia of the hip (DDH) occurs in 5.5 out of 1000 full-term babies within the first two days of life, 10% of whom continue to exhibit complications after 2 weeks of age[1]. The American College of Radiology clinical standard is to screen infants for DDH using clinical examination (Ortolani and Barlow) and ultrasound imaging. In infants diagnosed with DDH grades 1-3, the Pavlik Harness induces a flexed and abducted hip position and is the gold-standard of care for closed reduction with an 80-92% success rate[2]. The specific positioning of babies within the Pavlik harness contributes to proper hip development in babies with DDH. Therefore, it is reasonable to assume that other devices which place the hips in specific positions may also impact hip development. Babywearing, the act of carrying an infant in a device worn on a caregiver's body, places infant hips in varied positions depending on the design of the product. Some carriers subject infants to a flexed and abducted position (M-position) that may be similar to the position provided by the Pavlik harness, and communities who culturally babywear in this manner indicate a low incidence of DDH[3]. Other carriers feature a narrow base, and hip position in this style of carriers is unexplored. Our previous study utilized motion capture and electromyography to evaluate the biomechanics of infants and their hips within carriers, finding that infants exhibited similar hip position and muscle activity in inward-facing soft-structured baby carriers with M positioning and knee-to-knee support, compared to the Pavlik harness[4]. While motion capture provides an estimate of hip positional angles, these estimates are not as anatomically representative of hip position as coronal hip ultrasounds. *The purpose of this study was to utilize coronal hip ultrasound scanning to measure the alpha angle and femoral head coverage of healthy infants in the Pavlik harness and two inward-facing baby carriers.*

METHODS: Ten healthy full-term infants with no orthopaedic or neurological conditions (13.5±3.4 weeks, 5F/5M) were enrolled in this ongoing IRB-approved study. Coronal hip ultrasound scans were obtained using a Vscan with Dual Probe pocket-sized ultrasound device (GE Healthcare, Chicago, IL) from the infants in three conditions: (1) a Pavlik harness, and held in two inward-facing soft-structured baby carriers: (2) one with infants in the M-position with knee-to-knee support (Boba, Inc.; Fig. 1. A, D), and (3) one with a narrow base and without knee-to-knee support (Infantino LLC; Fig. 1. B, E). The baby carriers were modified to provide access to the ultrasound probe while retaining structural integrity. The coronal ultrasound scan images (Fig. 1. F) were de-identified, blinded to infant position, and independently assessed by a board certified pediatric orthopaedic surgeon (BR) to obtain the alpha angles and femoral head coverage. Repeated measures ANOVAs were used to compare the baby carrier and Pavlik harness data (dependent variables: alpha angle and femoral coverage, independent variables: Pavlik harness, M-position carrier, and narrow base carrier). The repeated measures ANOVAs were performed on data from the five participants (13.0±1.6 weeks, 3F/2M) from whom data were obtained for all three products, i.e., the Pavlik harness, the M-position carrier, and the narrow base carrier.

RESULTS: Mean and standard deviation of the alpha angle and femoral head coverage obtained from the testing are depicted in Fig. 1. G, H. Alpha angle was significantly different between the infant products tested, $F(2,8) = 8.315$, $p = 0.011$. A post hoc analysis (pairwise t-tests with a Bonferroni correction; significant at $p<0.0167$) found that the alpha angle difference between the Pavlik harness and the narrow base carrier was statistically significant ($p=0.0166$), while it was not significantly different between the Pavlik harness and the M-position carrier ($p=0.130$). Femoral head coverage was not significantly different between the infant products tested, $F(2,8) = 1.054$, $p = 0.392$. Alpha angles and femoral head coverage were lower, on average, for the narrow base carrier compared to the Pavlik harness and the M-position carrier (Fig. 1. G, H).

DISCUSSION: The lower alpha angle and femoral coverage in the inward facing narrow base baby carrier with no knee-to-knee support, compared to the Pavlik harness, agree with recommendations set forth by the International Hip Dysplasia Institute to limit prolonged use of baby carriers which do not support the knees (Fig 1. B). The similar alpha angles and femoral coverage in the inward facing M-position baby carrier with knee-to-knee support compared to the Pavlik harness, combined with the similar hip position and lower-extremity muscle activity recorded in our previous experimental study[4] using the same carrier, indicate possible applications for the use of similar baby carriers in DDH populations. Limitations of the study include a small sample size, occasional non-compliant subjects, and the inherent challenge of obtaining infant hip ultrasound scans from within infant products. Data collection of this study is ongoing, with a goal of recruiting 10 additional healthy infants and 10 infants with hip instability who are under observation by their pediatric orthopaedic provider. As parents continue to use infant devices, further research needs to be conducted on the musculoskeletal and biomechanical impact of infant positioning for both DDH and healthy infants.

SIGNIFICANCE/CLINICAL RELEVANCE: While orthopaedic devices like the Pavlik harness are the gold-standard for closed reduction of DDH in children under the age of 6 months, hip health for infants with mild DDH or in healthy populations are unexplored. The similar alpha angles and femoral coverage in soft-structured baby carriers with knee-to-knee support and M-positioning, when compared to the Pavlik harness, may indicate healthy hip positioning which should be further explored for healthy infants and those with hip instability or DDH.

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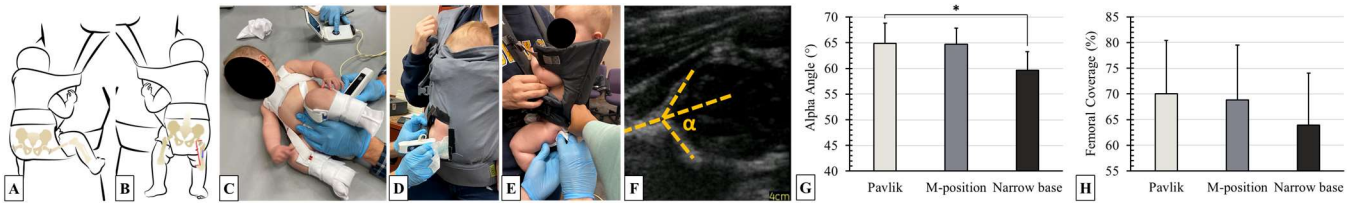

Fig. 1. Example of baby carrier with appropriate knee-to-knee support **(A)** and without knee support **(B)**, obtaining coronal hip ultrasound scans using a GE Vscan from infants in a Pavlik harness **(C)**, an inward M-position baby carrier **(D),** and an inward narrow base baby carrier **(E)**, example ultrasound scan **(F)**, and the calculated alpha angle **(G)** and femoral coverage **(H)** (mean ± SD; Bonferroni corrected significance at $p < 0.0167$).