Lower extremity hip position and muscle activity during babywearing in soft structured baby carriers: Implications for developmental dysplasia of the hip

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Introduction

- Developmental Dysplasia of the Hip (DDH) can occur in up to 25/1000 full term babies[1].
- Early detection and treatment is key, untreated DDH can cause degeneration of the hip joint in adulthood.
- Pavlik Harness (PH) is the gold-standard for treating DDH grades I-III with 80-92% success rate[3].
- Computational models show positive impact of active adductors on reducing DDH hips when hips are in the optimal 90° flexion and 80° abduction (M-position) in the Pavlik Harness[4].
- Devices like Pavlik Harness and Rhino Cruiser abduction braces are restrictive/uncomfortable for infants and problematic for parents to comply with as they require 24hr/day usage for up to 10 weeks.
- Babywearing with an inward-facing carrier often places infant hips in M-position like the Pavlik Harness, which may provide similar hip support and reduce DDH incidence[5].

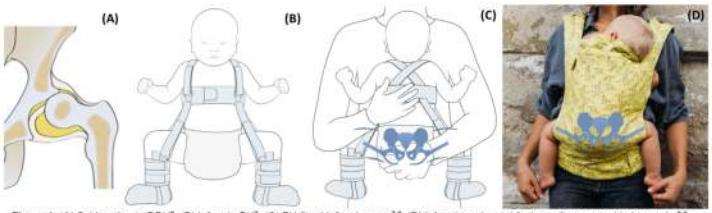
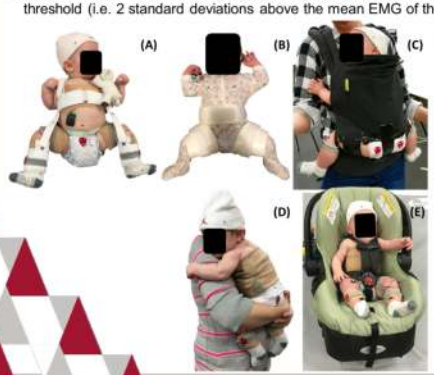


Figure 1. (A) Subluxation in DDH[6], (B) Infant in PH[7], (C) PH fitted infant in arms[7,8], (D) Infant in an inward-facing soft-structured baby carrier[8,9]

- A recent computational model demonstrated that good babywearing practice produces centrally located acetabular forces[10], which research shows is indicative of healthy hip joint development.
- No studies have evaluated infant hip biomechanics within carriers, containers and orthopedic devices.
- Can appropriate babywearing replicate the hip position and lower extremity muscle activity seen in PH?
- We measured the hip positions and lower-extremity muscle activity of infants in common DDH devices, in a standard car seat, held in arms, and in an inward-facing soft-structured baby carrier.

Methods

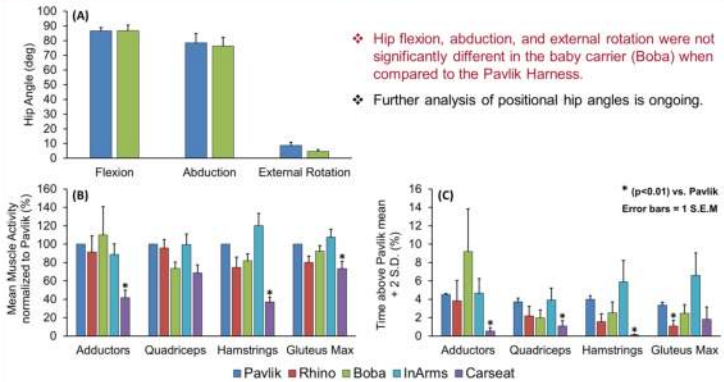
- 21 healthy full-term infants (4.1±1.5 months, 12M, 9F) were enrolled in the IRB-approved study.
- Lower extremity motion = Marker-based motion capture (Vicon, 100Hz).
- Muscle activity of adductors, quadriceps, hamstrings and gluteus maximus = Surface EMG (Delsys, 1000Hz).
- Hip angles = marker data used to define local coordinate systems of the hip and thigh segments, which were then used to calculate hip flexion, abduction and external rotation via an XYZ Cardan rotation sequence.
- EMG data was rectified, filtered, and normalized to the Pavlik Harness condition via custom MATLAB code.
- EMG variables = Mean EMG signal, and the percent time that muscles were active above the Pavlik threshold (i.e. 2 standard deviations above the mean EMG of those muscles when wearing a PH).



- After significant observations in one-way ANOVA with repeated measures, Paired t-tests were used post-hoc to compare all conditions to the Pavlik Harness condition ($p<0.01$).

Figure 2. *Infants participated in five 30-second data collection conditions:* (A) in a Pavlik Harness, (B) in a Rhino Cruiser[11], (C) held in an inward-facing soft-structured baby carrier (Boba, Inc.), (D) held in arms, and (E) in a standard car seat.

Results



- Hip flexion, abduction, and external rotation were not significantly different in the baby carrier (Boba) when compared to the Pavlik Harness.
- Further analysis of positional hip angles is ongoing.

Fig. 3. (A) Hip rotational angles for PH and Boba, (B) Mean muscle EMG normalized to PH, and (C) % time muscles active above PH mean + 2 SD

- Lower limb muscle activity, compared to Pavlik Harness, was not significantly different in the Rhino Cruiser, baby carrier (Boba), or in arms conditions, both in mean muscle activity and percent time above Pavlik threshold, except for the significantly lower gluteus maximus active muscle time in the Rhino Cruiser.
- Placing infants in a car seat resulted in significant negative differences; approximately half of mean muscle activity and 4 times less active muscle time compared to the Pavlik Harness condition for all muscle groups.

Discussion

- Hip angle values for the Pavlik Harness show agreement with the optimal 90° flexion and 80° abduction[4].
- In agreement with computational models, the Pavlik Harness and Rhino Cruiser resulted in similar high levels of mean adductor muscle activity, supporting their efficacy in reducing infant hips.
- Carrying infants in arms exhibited similar levels of muscle activity to the Pavlik Harness, but carrying position varied among parents; some infants were carried with hips flexed and abducted and some were not.
- Passive container-type infant devices may not promote active lower-extremity muscles in healthy infants.
- Limitations of the study include occasional non-compliant subjects, and a data collection length of only 30 seconds per condition, which may not be ideally representative of real-life scenarios.
- The similar hip position and lower extremity muscle activity observed in a soft-structured baby carrier with M-positioning, when compared to the Pavlik Harness, indicates appropriate babywearing may be a potential mechanism to promote healthy hip positioning and lower extremity muscle activity in the treatment of DDH.
- **Future research** includes the musculoskeletal and biomechanical impact of infant positioning in carriers, containers, and orthopedic devices for healthy infants using ultrasound.
- The effect of Pavlik Harness treatment on the hip positioning and lower extremity muscle activity of DDH infants will be also compared pre- vs. post- treatment, and against the healthy controls from our current study.

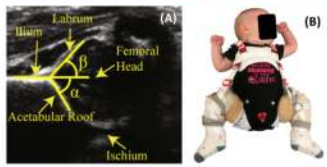


Fig. 4. (A) Coronal hip ultrasound[12], (B) DDH infant testing

Acknowledgements

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