

Evaluation of Q3s ATD Biofidelity as Compared to Volunteers and Hybrid III 3 Year-Old ATD

M. Ita, Y. Kang Ph.D.
The Ohio State University

INTRODUCTION

- Around 40% of child fatalities to rear-seated children ages 0-8 years old occur in side impact collisions [1].
- Child restraint systems (CRS) must be evaluated in the side impact condition with a side impact specific dummy to ensure child safety.
- The biofidelity of pediatric ATDs continues to be evaluated with scaled adult cadaveric data, an approach with questionable validity.
- The purpose of this study is to:
 1. Evaluate and quantify the biofidelity of a new side impact 3 year-old ATD, the Q3s, using adult data and pediatric volunteer data, and to compare these quantifications.
 2. Compare Q3s performance to that of the current 3 year-old standard ATD, the Hybrid III 3 year-old.

METHODS

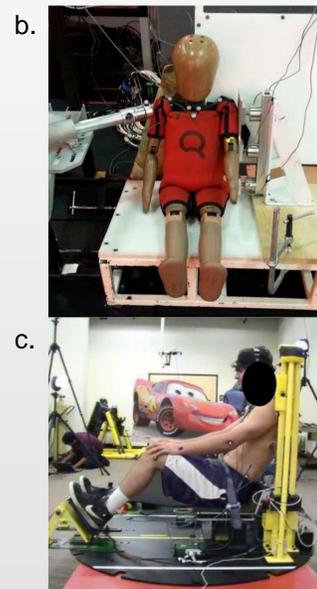
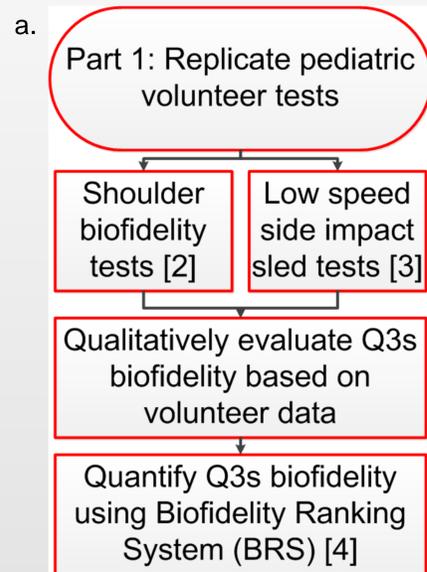


Figure 1: a) Schematic for Part 1 of the methods; b) quasi-static shoulder biofidelity test setup in oblique loading direction; c) Low speed side impact sled test setup in lateral loading direction with adult volunteer

REFERENCES

1. Carlson, M., Burleigh, M., Barnes, A., Waagmeester, K., Van Ratigen, M. (2007). Q3s 3 Year Old Side Impact Dummy Development. Paper number 07-205, 20th ESV Conference, Lyon, France.
2. Sunray, B., Moorhouse, K., and Bolte, J. (2011) Characterization of the pediatric shoulder's resistance to lateral loading conditions. 22nd International Technical Conference on the Enhanced Safety of Vehicles, Paper No. 11-0038.
3. Arbogast, K.B., Mathews, E.A., Seacrist, T., Maltese, M.R., and Hammond, R. (2012) The effect of pretensioning and age on torso rollout in restrained human volunteers in far-side lateral and oblique loading. Stapp Car Crash Journal 56: 54-79.
4. Sullivan, L.K. and Loudon, A.E. (2009) NHTSA's initial evaluation of child side impact test procedures. National Highway Traffic Safety Administration, Paper No. 09-0539.
5. Rhule, H.H., Maltese, M.R., Donnelly, B.R., Eppinger, R.H., Brunner, J.K., and Bolte, J.H.IV. (2002) Development of a New Biofidelity Ranking System for Anthropomorphic Test Devices. Stapp Car Crash Journal 46: 477-512.

ACKNOWLEDGEMENTS

Yun Seok Kang, PhD, OSU
Thomas Seacrist, CHOP
Eric Dahle, Evenflo
Kevin Moorhouse, PhD, VRTC
Students and staff of the IBRC

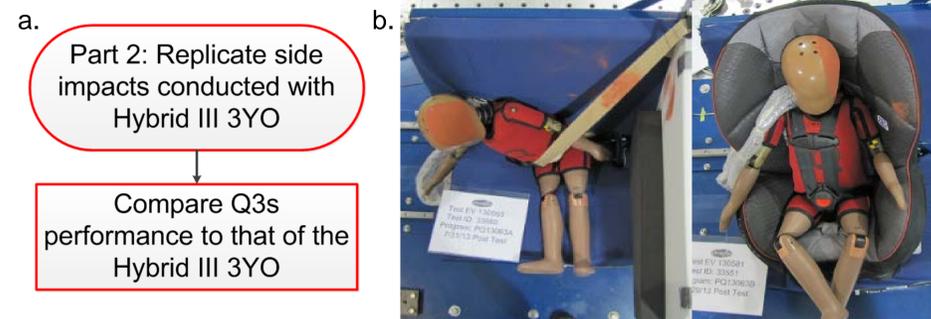


Figure 2: a) Schematic for Part 2 of the methods; b) Q3s post-test images from high speed sled test impacts in the lateral direction without CRS (left panel) and in the oblique direction with CRS (right panel)

RESULTS & DISCUSSION

Can we validate deflection measurements obtained with motion capture using the linear potentiometer in the Q3s shoulder?

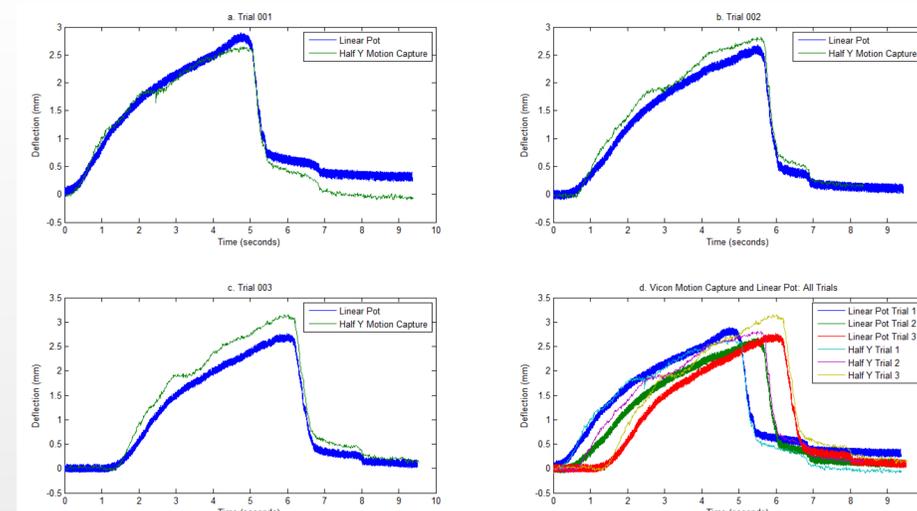


Figure 3: a-c) Deflection time courses (trials 1-3) for quasi-static shoulder biofidelity tests in the lateral loading direction. The linear pot was mounted from the shoulder to the Q3s spine and the Half Y motion capture curve indicates right acromion to sternum displacement; d) All trials plotted together

How does calculated Q3s shoulder stiffness compare to volunteer data?

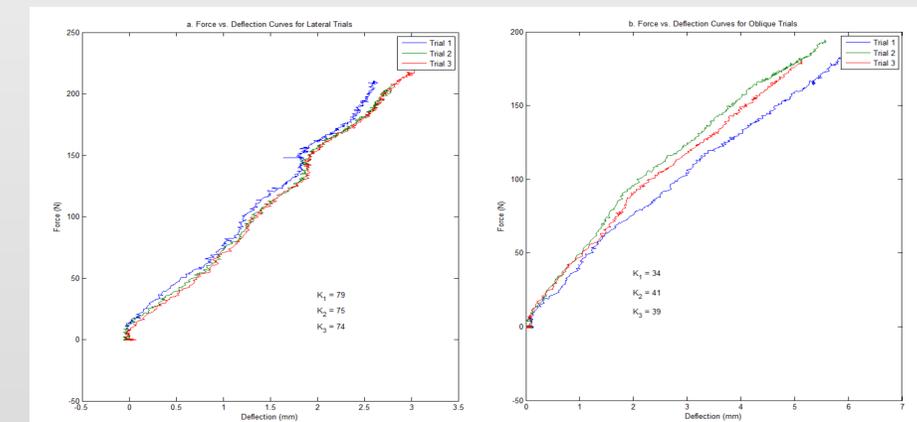


Figure 4: F-D curves for a) lateral impact trials and b) oblique impact trials. For stiffness calculations the acromion to sternum Y, and XY, vectors were used for lateral and oblique, respectively

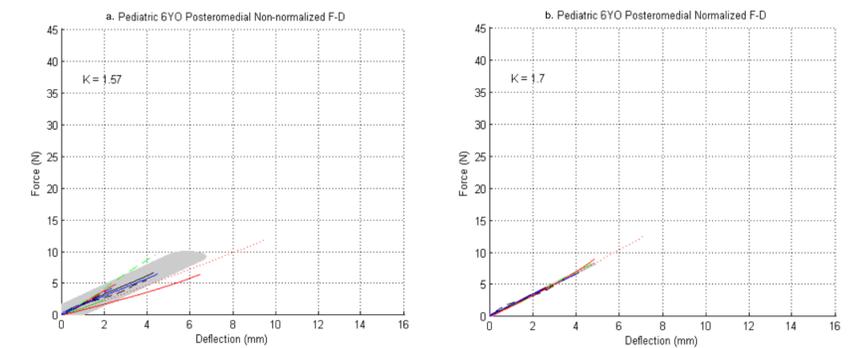


Figure 5: F-D curves for the oblique loading direction, both non-normalized (a) and normalized (b) with calculated stiffness values for previously collected 6 year-old volunteer data in quasi-static shoulder tests [2]

How do shoulder and thorax deflections compare in higher impact sled tests?

Table 1: Preliminary shoulder and thorax deflection data from high, medium, and low speed impacts conducted at lateral and oblique loading angles with and without a CRS. These data are from the sled tests that will later be used to compare Q3s to Hybrid III performance. Cell color ranges from green (smallest deflection/least severe) to red (largest deflection/most severe).

		Forward-facing with CRS		Forward-facing w/o CRS	
		Shoulder pot (mm)	IR-TRACC (mm)	Shoulder pot (mm)	IR-TRACC (mm)
Lateral (90°)	Low	0.6	1.75	0.9	0.8
	Medium	4	9	6.5	20
	High	8	14	7	33
Oblique (60°)	Low	0.5	0.8	0.7	1
	Medium	3.5	5	6.5	8
	High	6	9	10	35

CONCLUSIONS

- Although limitations exist with the Q3s shoulder potentiometer (limited to one axis measurements), Vicon marker motion capture has shown to be repeatable and accurate and allows for 2D deflection calculations.
- Preliminary Q3s lateral vs. oblique calculated shoulder stiffness values do not agree.
- Preliminary Q3s shoulder stiffness values vary significantly from pediatric shoulder stiffness values.
- Further analyses will provide insight into fully quantifying the Q3s shoulder biofidelity.
- Future work includes moving deeper into the data analysis stage of this project to complete 1. qualification and quantification of Q3s biofidelity with various volunteer datasets, and 2. Q3s comparison to Hybrid III.