PMHS Shoulder Stiffness Determined by Lateral and Oblique Impacts

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INTRODUCTION

- While side impacts are second in frequency for total motor vehicle crashes, side impacts have a higher mortality rate than other crash types[1,2]
- In the study of the side impact, it is important to consider both lateral and oblique loading conditions; the oblique vector may result in more injuries[1]
- The shoulder girdle is an important factor in determining the response of other parts of the body to lateral and oblique loading conditions[2]
- Past research has shown that the scapula may be responsible for absorbing impact energy[2]
- Study objectives include 1) comparing PMHS & adult volunteer quasi-static (QS) data, 2) comparing PMHS quasi-static & dynamic data, and 3) comparing PMHS lateral & oblique dynamic data
- In the future, these datasets will aid in developing a more biofidelic shoulder model for both adult and pediatric ATDs

METHODS

Quasi-static testing → **Modeled after a previous QS adult volunteer study[3]**

Dynamic testing → **Modeled after a previous dynamic PMHS study[4]**

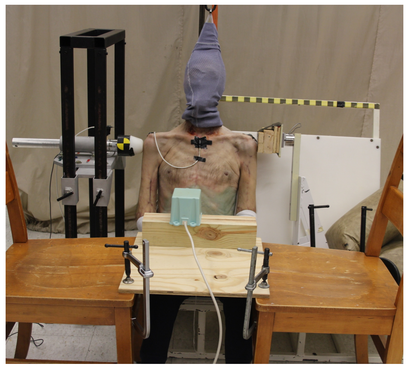

Figure 1: Quasi-static test set-up

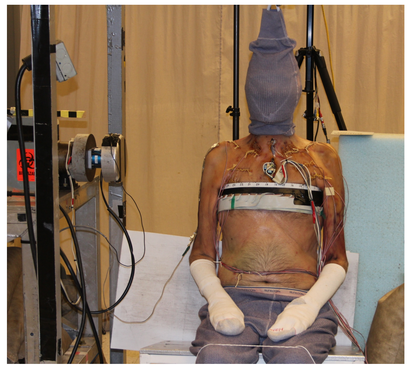

Figure 2: Dynamic test set-up

REFERENCES

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3. Suntay, B., Moorhouse, K., Bolte IV, J. (2011). Characterization of the pediatric shoulder's resistance to lateral loading conditions. *Enhanced Safety of Vehicles*. Washington, D.C.
4. Bolte IV, J., Hines, M., Herriott, R., McFadden, J., Donnelly, B. (2003). Shoulder impact response and injury due to lateral and oblique loading. *Stapp Car Crash Journal, 47*: 35-53.

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RESULTS & DISCUSSION

QS – Oblique Loading Condition

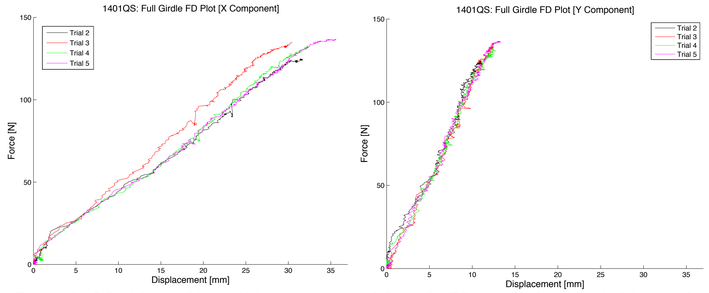

Figure 3: QS oblique (X- and Y-components) full girdle FD curves for Test 1401, 4 trials

Table 1: QS Oblique Full Girdle Stiffness (K) Values

Test	K_X (N/mm)	K_Y (N/mm)
1401	2.1	9.5
1402	1.0	11.2
Average	1.5 ± 0.8	10.3 ± 1.2
Previous Study[3]	1.6	7.0

- $K_Y > K_X$ due to the anatomical structure of the clavicle and the scapulothoracic joint

Dynamic – Lateral Loading Condition

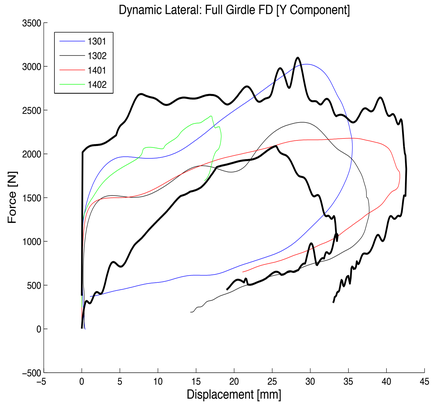

Figure 4: Dynamic lateral full girdle force-displacement curves

Table 2: Dynamic Lateral Full Girdle Stiffness Values

Test	K (N/mm)
1301	132.0
1302	97.5
1401	90.5
1402	219.0
Average	135 ± 59

- Current FD curves fit the target corridors from the previous study[4]

Dynamic – Lateral vs. Oblique Impacts

Table 3: Injuries from Dynamic Testing

	Impact Shoulder		Joints		Bones	
Test	**Lateral**	**Oblique**	**SC**	**AC**	**Ribs**	**Scapula**
1301	R.	L.	L./**R. laxity**	-NA-	-NA-	-NA-
1302	L.	R.	**L. laxity**	**L. laxity**	**L6**/R7 **fx**	**L. coracoid fx**
1401	R.	L.	L./**R. laxity**	-NA-	**R2/R3 fx**	-NA-
1402	L.	R.	**L. laxity**	-NA-	-NA-	-NA-

*R. = right; L. = left

Dynamic – Oblique Loading Condition

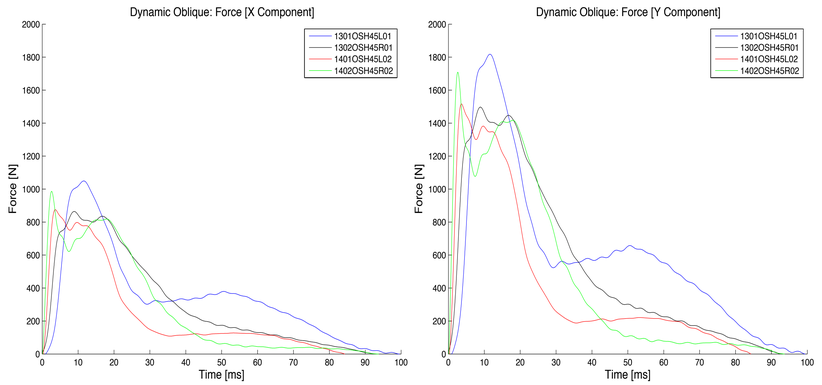

Figure 5: Dynamic oblique force (X- and Y-components) vs. time curves

Dynamic – Oblique Loading Condition (continued)

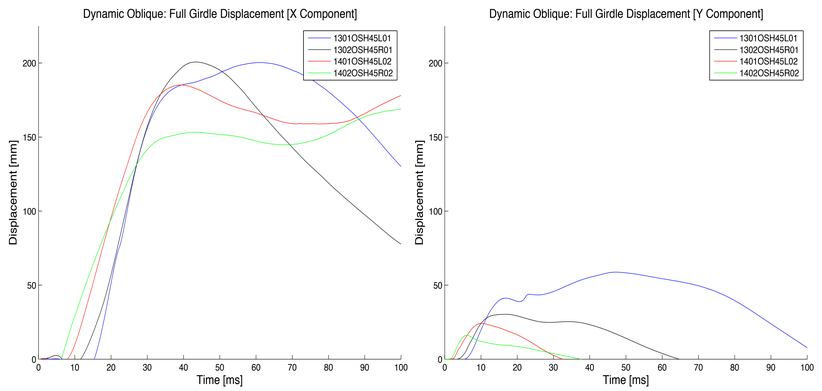

Figure 6: Dynamic oblique full girdle displacement (X- and Y-components) vs. time curves

CONCLUSIONS

- This study is ongoing; one more PMHS will be tested and dynamic data will be normalized to the 50th percentile male
- Limitations: small sample size (QS: n = 2; dynamic: n = 4), QS DAQ metal sensitivity, inaccurate method of measuring the QS lateral vector, non-normalized dynamic data
- QS data indicates a similar response of the PMHS and adult volunteer shoulder in the oblique loading condition (as compared to the volunteer's relaxed muscle state)
- The oblique vector in both QS and dynamic testing exhibited a lower force, higher displacement, and lower stiffness in the X-component compared to the Y-component
- At at an impact speed of 4.5 m/s, it is difficult to make a correlation between the lateral and oblique impact vector according to injury patterns