PMHS Shoulder Stiffness Determined by Lateral and Oblique Impacts

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Abstract

Data are desired that accurately represents the pediatric population for anthropomorphic test devices (ATD). Current pediatric ATDs are designed from scaled-down adult data, but the biofidelity is questioned. While pediatric volunteer tests are an appropriate measure to take, dynamic testing is not a valid option. Because the use of pediatric cadavers is an ethical issue, different methods of testing are required to gain an understanding of what the pediatric response would be. The dataset from this study will ultimately lead to a relationship that can predict an appropriate pediatric model of the shoulder for a more biofidelic ATD. The data from this study will allow for (1) a comparison between post mortem human subject (PMHS) quasi-static and dynamic testing, (2) a comparison between adult volunteer and PMHS quasi-static data, and (3) a comparison between lateral and oblique loading conditions.

This study has two testing phases; side impacts of the fiftieth percentile male are conducted in both quasi-static and dynamic manners. The impact is delivered in both purely lateral and 30° oblique loading conditions for each test. Quasi-static testing will identify the differences between adult volunteer and PMHS responses while dynamic testing will confirm PMHS response at the non-injurious threshold. With the application of a light load (100 Newtons) to the impacting shoulder in quasi-static testing, translational data is acquired from sensors fixed to bony landmarks (the acromion processes and manubrium). The data acquisition system used is the Flock of Birds, which utilizes a magnetic field emitted from a transmitter to detect movement of the sensors. In dynamic testing, the PMHS is instrumented with a triaxial accelerometer block on each acromion process, the manubrium, and T1, twelve strain gages placed on ribs 2-5 and medial and lateral clavicles bilaterally, and a chest band in the superior axilla. A 4.5 m/s impact is delivered through a pneumonic ram to one shoulder in the lateral loading condition while the opposing shoulder is then impacted at the same speed in the oblique loading condition.

For all tests, the full and half girdle deflections are calculated to determine overall displacement from impact. Full girdle displacement is represented as the difference between the opposing and impacting acromion while the half girdle displacement is represented as the difference between the sternum and the impacted acromion. The output of a force-deflection plot is generated and stiffness values are calculated from the linear portion of the plot (20-80% of the deflection). The stiffness values will be compared to previous studies, including Suntay et al. (2010) and Bolte et al. (2000). Injuries resulting from dynamic testing will be included to demonstrate differences between lateral and oblique impacts. To date, quasi-static stiffness in the lateral direction is higher than the adult volunteer data (15.06 N/mm compared to 10 N/mm) while dynamic stiffness in the lateral direction is lower than what has been seen in previous studies (111.83 ± 26.67

N/mm compared to 147 ± 77 N/mm). Injuries include loose sternoclavicular joints and a few rib fractures on the lateral impact side.