

The lack of sex, age, and anthropometric diversity in neck biomechanical data

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Background

Female, elderly, and obese individuals are at greater risk of neck injury in equivalent automotive collisions. Development of safety technology to protect these occupants requires high quality data from a wide range of subjects.

Objective

In this work, we sought to quantify the sex, age, and anthropometric characteristics of volunteers and cadavers that make up the available neck (head in reference to torso) kinematic data.

Methodology

A systematic search of the literature and biomechanical databases was performed for studies that contained kinematic data for the head and torso in response to inertial loading and direct head and body impacts, and from which the neck response could be estimated. This search was conducted for the development of kinematic corridors for an omnidirectional surrogate neck (see abstract by S. Romani). We compiled the sex, age, height, weight and body mass index (BMI) of 626 volunteers and 110 post-mortem human subjects (PMHSs) exposed to more than 5,600 impacts from 60 published studies and three biodynamic test databases (National Biodynamics Laboratory, Air Force Biodynamic, and National Highway Traffic Safety Administration Biomechanics). These characteristics were then compared to reference data from the US population, US automotive fatalities, and US automotive neck injuries extracted from three additional databases (US Census Bureau, Fatality Analysis Reporting System, and National Automotive Sampling System).

Results

66% of the volunteer tests and 84% of the PMHS tests were conducted with male subjects. Male individuals made up 50% of all of the US automotive neck injuries (AIS1+) and 63% of serious neck injuries (AIS3+). The average ages for the male and female volunteers were 26 and 27 years old, respectively, whereas the average ages of male and female PMHSs were 63 and 69 years old. In contrast, the average ages for serious neck injuries as a result of automotive collisions in the US are 38 and 42 for males and females, respectively. A small number of male child and adolescent volunteers (6-17 years old) have been tested, but the youngest female subject captured in our dataset was 18 years old. While the average BMIs across the volunteer, PMHS, injury, and fatality distributions were approximately equal within male and female groups ($\sim 25 \text{ kg/m}^2$), their variances were substantially smaller in the volunteer and PMHS2 datasets. The standard deviations for the males and females were 3.4 and 3.1 kg/m^2 in the volunteers and 4.6 and 5.1 kg/m^2 in the PMHSs, but reached 7.0 and 6.6 kg/m^2 in the US population with serious neck injuries.

Conclusions

This work highlights the male bias in the neck biomechanical data from volunteers and PMHSs (especially for children and adolescents) and the small dispersion of anthropometric characteristics (especially in volunteer and male PMHS testing) relative to the neck injured population. Increasing the diversity of subjects used for biomechanical testing is vital for creating research tools (e.g., dummies and computer models) and designing safety interventions (e.g., seat belts, airbags, head restraints) to protect all members of society.