Developing Pediatric ATD Thoracic Biofidelity Requirements from Cardiopulmonary Resuscitation Data

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ABSTRACT

Obtaining accurate pediatric thoracic force deflection characteristics is critical for the development of biofidelic pediatric anthropometric test devices (ATD) used in designing motor vehicle safety systems. Owing to the paucity of pediatric post-mortem human subjects (PMHS) for research, such characteristics in modern pediatric ATD's are based on scaled adult PMHS data. However, such scaling processes give limited consideration to the tissue and morphological differences associated with human maturation. In the clinical setting, the magnitude of chest compressions on pediatric subjects undergoing cardiopulmonary resuscitation (CPR) are in the range of chest deflection limits in Federal frontal crash test regulations. Thus, the goal of this study is to describe analytical methods and preliminary data from 16 children undergoing CPR, towards a biofidelity design standard for the pediatric ATD thorax. A novel force and deflection sensor has been integrated into a clinical monitor-defibrillator used during CPR at the Children's Hospital of Philadelphia. The sensor is interposed between the chest and hands during CPR compressions, and is designed to provide real-time feedback to improve the quality of CPR. Thoracic force and compression data are downloaded from the monitor-defibrillator for analysis following a CPR event. Each compression is fit to a parallel spring-damper model, wherein stiffness and damping are linearly dependant on depth. Sixteen CPR cases were recorded, consisting of 31,535 compressions. Maximum applied force ranged from 37 N to 613 N, and chest compressions from 15 mm to 76 mm, and compression velocity from 0.044 m/s to 0.64 m/s. The preliminary mean linear stiffness of the pediatric thorax was 7343 (Standard Deviation SD: 3709) N/m. This study provides a promising method with which to measure the biomechanical properties of a live pediatric thorax, with the potential to improve the accuracy of pediatric ATD's.