Pediatric Neck Muscle Strength and Endurance

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ABSTRACT

Introduction:
Neck mechanics is central to head injury prevention since it is the musculoskeletal neck, which dictates the position and movement of the head. Child head injury prevention is particularly difficult due to the differential head-to-neck allometry – head circumference of a 4-year-old is 90% of its adult value while the neck circumference does not approach 90% of adult until age 14. Therefore, the objective of this human-subject study was to measure the anthropometry and mechanics (strength and endurance) of the developing neck musculature.

Methods:
A factorial study design was performed on 69 human subjects where anthropometry (height, weight, and head-neck dimensions) was recorded and strength and endurance were measured in three directions (flexion, extension, lateral bending) as a function of age (6-24 years). Using a custom designed testing device, including a six-axis load cell, each subjects' neck maximum voluntary contraction was measured in triplicate. Following this test, an endurance test measured the subjects' ability to apply 70% of their peak force for 30 seconds.

Results:
Linear regression of peak force ($p<0.012$) and endurance ($p<0.003$) as a function of age revealed each direction to be statistically increasing with age (F-test). The peak force, averaged across direction, advanced with age by the following function: Average Peak Force (N) = 2.34(age) +35.29. Similarly, the endurance (percentage of peak force at 30 seconds) exhibited the following function with age: %Peak Force = 1.58(age) +29.66. The anthropomorphic measurements also increased with age similar to data found in the literature.

Discussion:
Child neck muscle strength and endurance increase with maturation. Our results predict that a 4-year-old child with a 90% adult head size is only capable of producing 54% of the adult peak neck force. Further, the child neck muscles appear to fatigue earlier than adults. These relationships will facilitate more accurate modeling of the head-neck complex and improved design of head injury prevention interventions.