Effect of Neck Position in Sagittal Plane Isometric Strength of Paediatric and Adult Female Subjects

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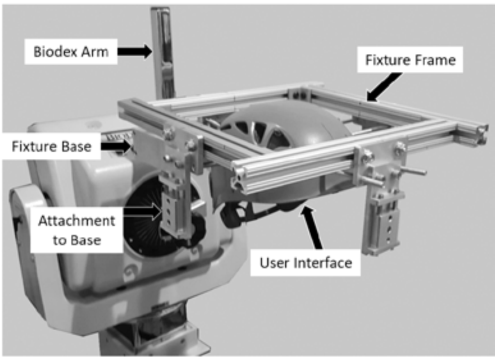
I. INTRODUCTION

Paediatric and female vehicle occupants have increased vulnerabilities in motor vehicle crashes when compared to adult males [1-2]. This increased vulnerability may be partially attributed to a gap in understanding of experimental responses of these populations. Furthermore, experimental data of neck strength in non-symptomatic paediatric and adult female subjects are seldom available, much less in direct comparisons. Often, adult female and paediatric data used for kinematic predictions are scaled from adult male data. This study aims to provide direct comparisons of paediatric and adult female isometric neck strength in the sagittal plane for three unique neck positions.

II. METHODS

This study was approved by the Institutional Review Board (IRB) at Ohio State University (Project #2016H0300). Twenty-five children (mean age: 5.8 ± 0.7 years; range 5–7 years) and 15 adult females (mean age: 24.5 ± 6.3 years; range: 20–40 years) were recruited for this study. Exclusion criteria were neck injury within the last year, neck surgery within their lifetime, excessive kyphosis, and, for the adult females, neck girth < 56 cm, to ensure that both groups could use the same testing fixture.

Isometric strength was assessed using a custom head fixture retrofitted on a Biodex Isokinetic Dynamometer (Biodex Medical Systems Inc., Shirley, New York) (Fig. 1(a)). Strength measurements were quantified in neutral neck position (0° of axial deviation), mid-range of motion (30°) in flexion, and mid-range of motion (30°) in extension. All subjects completed three repetitions of 5 s maximum hold contractions, with 5 s of rest between repetitions. Adult female subjects engaged with the testing equipment in flexion and extension for all neck positions, while paediatric subjects only engaged with the testing equipment in the same direction as their neck position (only flexing when flexed and only extending when extended) (Fig. 1(b)). For all subjects, isometric strength was defined as the peak torque value for all viable repetitions.

(a) 

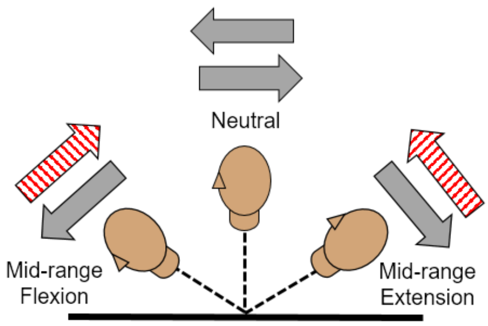
(b) 

Fig. 1. (a) Custom head fixture retrofitted on a Biodex Isokinetic Dynamometer. (b) Subjects' efforts in each neck position. (Red arrows: adult only.)

III. INITIAL FINDINGS

Paediatric subjects were representative of a 50th percentile child in both size and weight, while adult females were representative of a 55th percentile female in stature and 26th percentile female in weight. Subjects were significantly stronger in extension than in flexion for all neck locations. Adult female subjects were significantly stronger than paediatric subjects for all comparable locations (Table I). On average, adult females were twice as strong as the paediatric subjects. The largest difference in strength was seen when extended at mid-range of motion, with adult females being 2.3x stronger than the paediatric subjects. Adult females showed increased

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isometric strength in flexion when they were flexed at mid-range of motion, and increased strength in extension when they were extended at mid-range of motion. Paediatric subjects had comparable strength in extension when in neutral and extended neck positions.

TABLE I
ISOMETRIC STRENGTH (NM)

Subjects		Mid-Range (30°) Flexed		Neutral (0°)		Mid-Range (30°) Extended	
	Effort	Flexion	Extension	Flexion	Extension	Flexion	Extension
Adult Females	Avg	13.85	15.26	7.75	17.88	4.08	21.77
	SD	2.53	3.78	1.76	3.93	1.78	3.85
Paediatric	Avg	7.66		3.48	9.59		9.58
	SD	1.91		2.17	4.60		2.99
Adult Males* [4]	Avg	15.45	52.04	23.34	45.29	22.75	42.18
	SD	5.58	14.58	4.93	11.46	4.87	9.42

*Mid-range data for adult males were collected at 20° of axial deviation

IV. DISCUSSION

All subjects were stronger in extension than in flexion. Differences in strength can be attributed to differences in the amount and size of muscles engaged to achieve each motion. Neck flexion is achieved by engaging the sternocleidomastoid and scalene muscles. The flexor muscles, that is the bilateral sternocleidomastoid, scalene and other smaller muscles, are relatively small as their origins and insertions are roughly within the length of the neck. To extend the neck, larger muscles such as the trapezius, splenius cervicis, longissimus cervicis and semispinalis cervicis are engaged. The extensor muscles have increased biomechanical advantage to produce more force because not only are they larger and extend further than the neck region, but they also have a larger area and physiologic cross-section [3].

Direct strength comparisons between the subjects were not possible for all strength measurements. The paediatric subjects did not perform isometric extension when in the flexed position, nor did they perform isometric flexion when in the extended position due to the difficulty of performing these tasks for this age group. Adult females were stronger than the paediatric subjects in all comparable measurements. When compared to available literature of similar strength assessments, adult males are considerably stronger than the adult females and the paediatric subjects [4]. These trends in strength differences between adult and paediatric males and females have been reported previously [5]. Overall, adult females were more similar to children in strength than to adult males. Accordingly, caution should be exercised when scaling neck moments linearly from adult male data. Future studies should focus on the quantification of experimental female neck moment corridors and on using the female data as the reference population when scaling paediatric responses.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

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