

# NECK LOADING OF A CHILD IN A CAR SEAT

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# INTRODUCTION

- Babies and infants lack full control of their neck muscles
  - Head slumps while sleeping in car seat
  - Hyperextension of neck muscles
    - Neck pain
  - Pinched trachea
    - Positional asphyxia



Baby's Head Position Affects Breathing

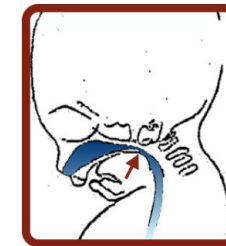
THE CAR SEAT LADY

Chin Up



Airway Open

Chin-to-Chest



Airway Blocked

Images adapted from: Tonkin SL. NZ Med J 1998

# EXISTING SOLUTIONS

- Manually reclinable car seats
  - Hard to recline and inconvenient
- Rear-facing car seat
  - Not convenient and lack of space
- Neck pillows
  - Uncomfortable and restricts movements
- Headband attached to car seat
  - Discomfort and lack of freedom



# CAR SEAT REGULATIONS

- All children four years old and under must ride in child safety seats

- Safety seats must be certified according to Federal Motor Vehicles Safety Standard No. 213

- Federal Motor Vehicle Safety Standard No. 213

- Head injury criteria
  - Head excursion
  - Force on chest

This child restraint system conforms to all applicable Federal Motor Vehicle Safety Standards. For use in motor vehicles.

**This Restraint is NOT certified for use in Aircraft.**

Este sistema de sujeción infantil cumple con todas las Normas Federales de Seguridad Para Vehículos Motorizados correspondientes. Para uso en vehículos motorizados.

**Este Sistema de Sujeción NO está certificado para ser Usado en Aviones.**



# LITERATURE REVIEW

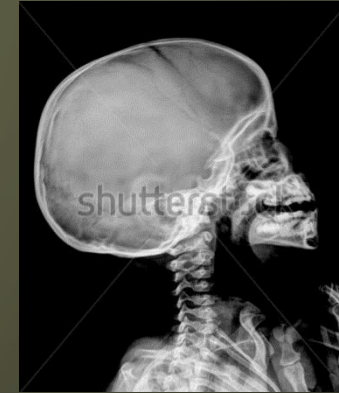
- A study conducted in a hospital found that children between the ages of 1 month to 3 years old (average 10 months old) were more susceptible to asphyxia<sup>[1]</sup>.
- A study on hazards with sitting devices showed 66% of deaths occurred in car seats – 48% due to positional asphyxia<sup>[2]</sup>.

[1] Byard, R.W. [1996]. Hazardous Infant and Early Childhood Sleeping Environments and Death Scene Examination. *Journal of Forensic Medicine*, 115-122.

[2] Batra, E. K., Midgett, J. D., & Moon, R. Y. (2015). Hazards associated with sitting and carrying devices for children two years and younger. *The Journal of Pediatrics*, 167(1), 183-187.

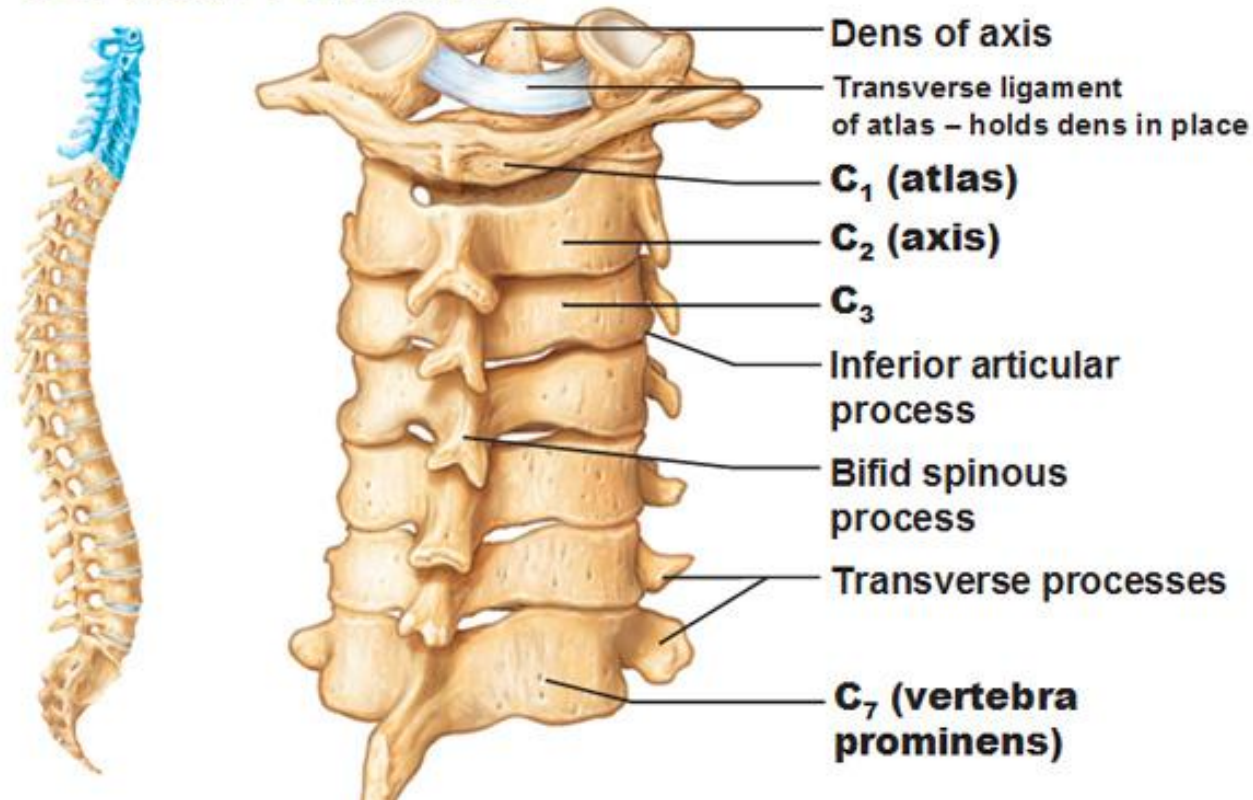
# OBJECTIVES

- Analyze head and neck position associated with slumping
  - Neck discomfort
  - Asphyxia
- Develop a motorized car seat
  - Monitors heart rate to detect sleep
  - Reclines car seat to more comfortable position
- Create a Graphical User Interface (GUI)



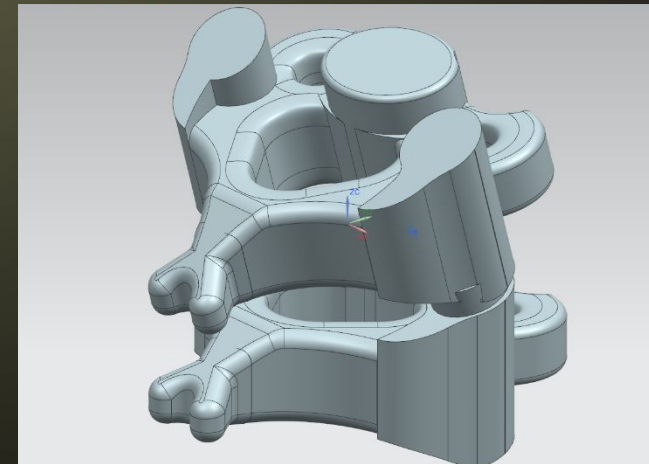
# NECK ANATOMY

## Cervical Vertebrae



# METHODS

- Create a model of the head and neck
  - NX11
  - Realistic representation of neck
  - Vertebrae, ligaments, muscles
- Create a model circuit of the motorize car seat
  - Utilize Arduino Microcontroller
  - Model smart device application





# SCHEMATIC

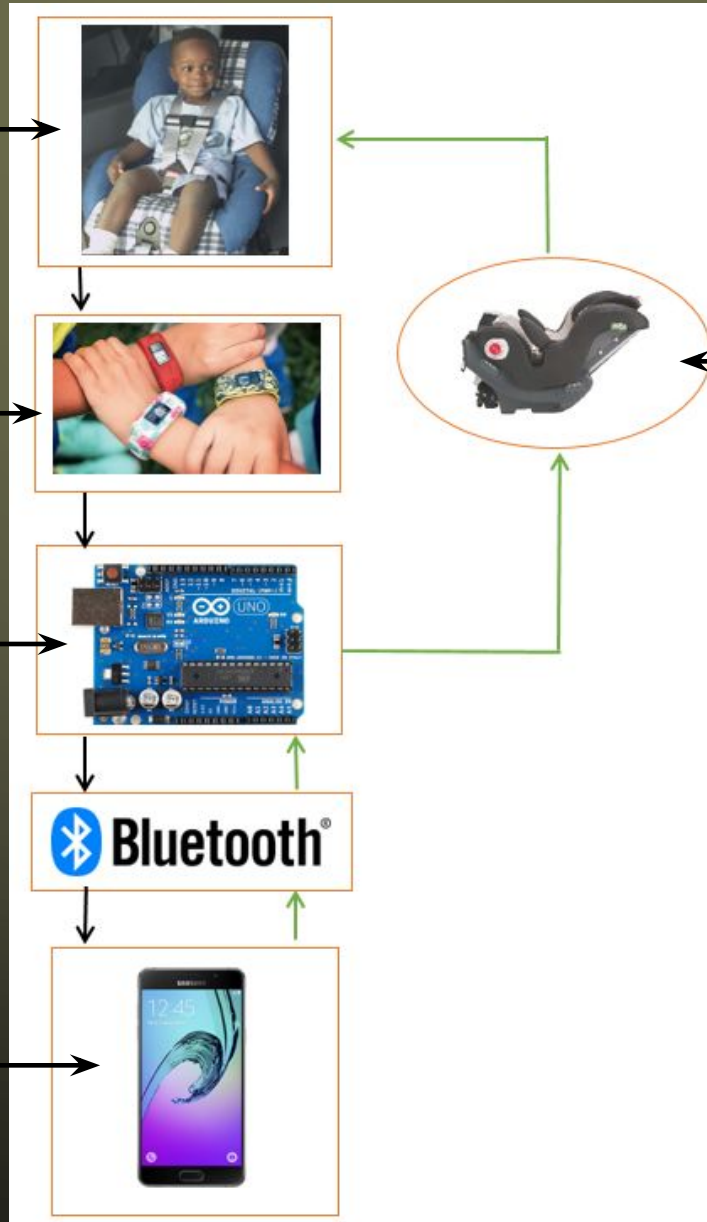
Child in Car Seat

Pulse Sensor

Arduino  
Microcontroller

Smart Device

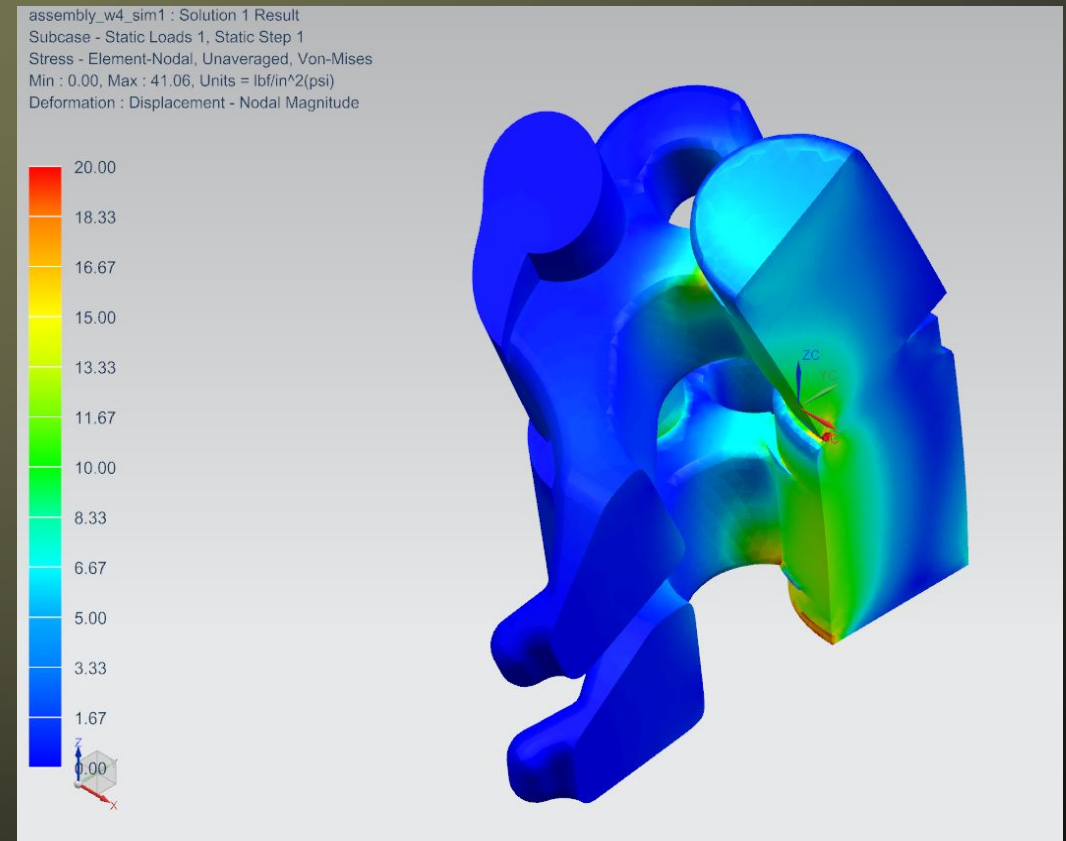
Reclined seat



# RESULTS

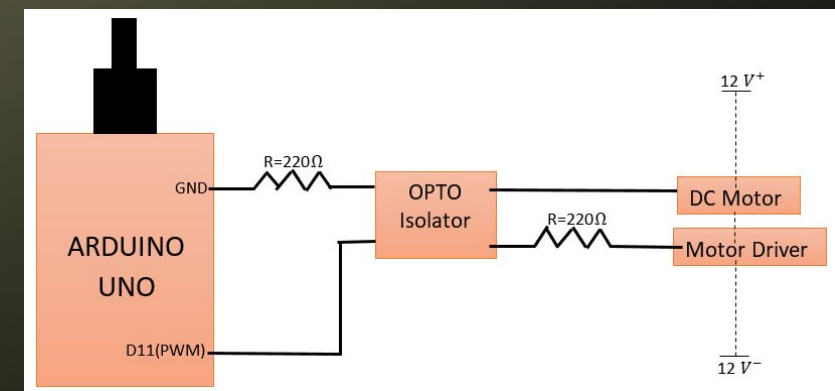
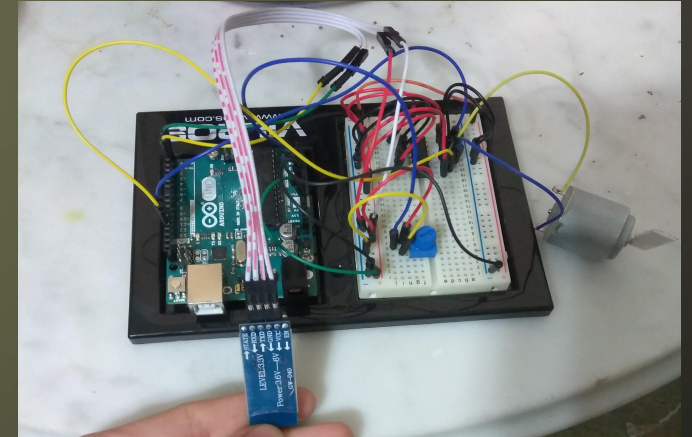
- Analysis of the vertebrae simulation

- Muscles and ligaments experience excess strain and stresses
- Pinched trachea
- Violent acceleration and decelerations cause harm
- Highest stress occurred in the soft area between the vertebrae



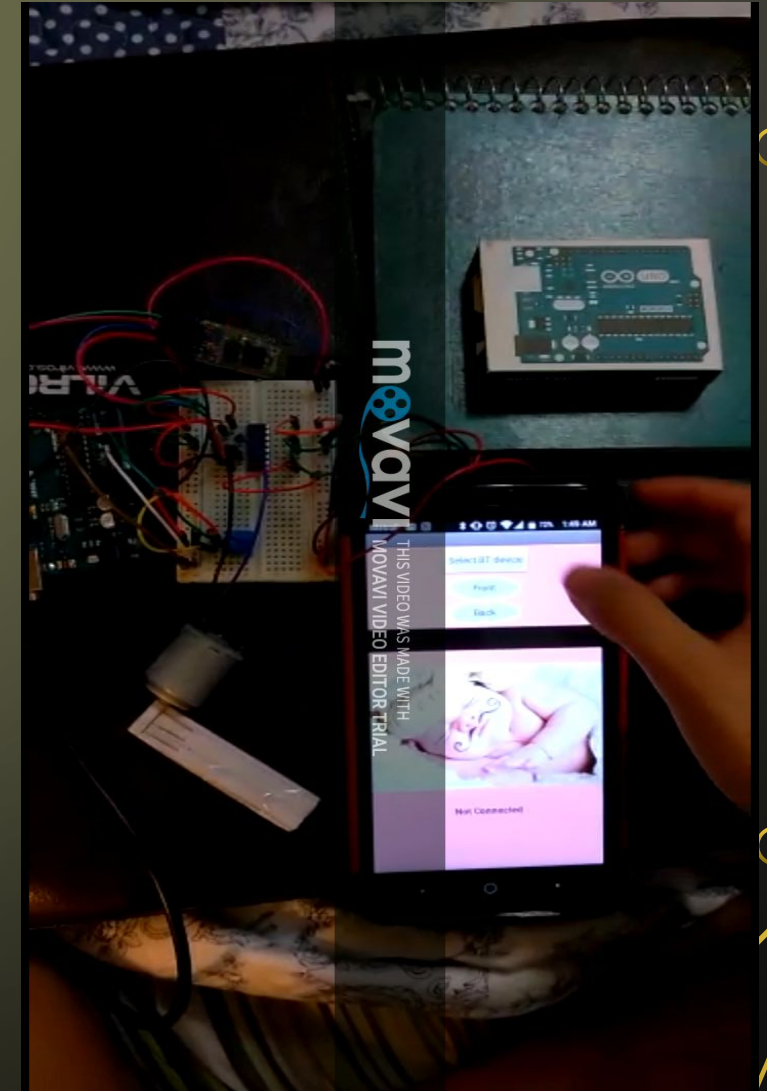
# RESULTS

- Design of seat operation
  - Servo motor reclining mechanism, motor control, pulse rate sensor and communication system
  - Pulse sensor detect sleeping pulse, alerts parent
  - Successful detection of child's pulse and control of motors



# RESULTS

- Graphical User Interface (GUI) Design
  - User activates communication system via Bluetooth
  - Application monitors child's pulse rate
    - Displays notification if child is asleep.
  - User has option to recline seat using smart electronic device.
    - Controls how far back or front the chair is positioned.





# CONCLUSION

- Problem

- Slumped position of a child's head causes harm to his/her neck
  - What areas are experiencing the most stress and strain?
  - Existing solutions to problem can be inconvenient
  - Uncomfortable for child

- Analysis

- Highest stress occurs at the disk location
  - Worse as automobile accelerates and decelerates

- Solution

- Design of motorized car seat
  - More convenient for both parents and child
  - GUI design for remote chair control

# WHAT'S NEXT?

- Conduct more research
  - Better understand the effects of the chin to chest position
- Build a prototype car seat
  - Conduct tests for functionality and performance
  - Test circuit with a large scale DC motor
- Product Development
  - Possibility to expand?
  - Work with Strategic Innovation Learning Center (SILC) for a market design



# ACKNOWLEDGEMENTS

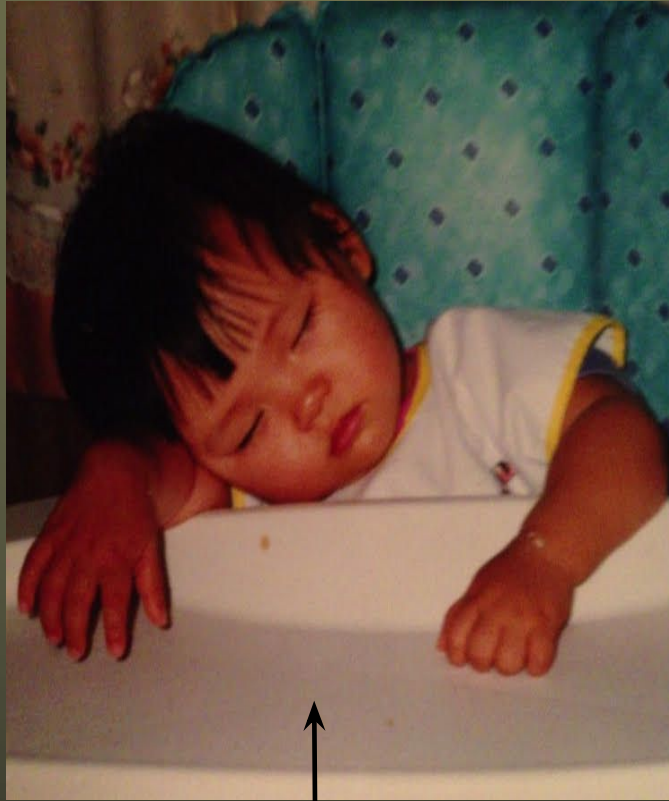
- Dr. Parisa Saboori
- Dr. Graham Walker



# THANK YOU



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# ANY QUESTIONS?



# REFERENCES

- [1] Batra, E. K., Midgett, J. D., & Moon, R. Y. (2015). Hazards associated with sitting and carrying devices for children two years and younger. *The Journal of Pediatrics*, 167(1), 183-187.
- [2] Byard, R.W. (1996). Hazardous Infant and Early Childhood Sleeping Environments and Death Scene Examination. *Journal of Forensic Medicine*, 115-122.
- [3] Hubbs-Tait, L., Peek, G. (2017). Protecting Infants and Toddlers from Positional Asphyxia: Car Seats and Sling Carriers, 1-4.
- [4] Nayeri, F., Shariat, M., Salili, H., Adam, L.B., Mehrjerdi, F.Z., Shakeri, A. (2012). Perinatal Risk Factors for Neonatal Asphyxia in Vali-e-Asr Hospital, Tehran-Iran, 137-140.