Investigating the influence of neck strength on head trauma in rear body-first falls

Kate Gilliland
PS/C, CA208, University of Ottawa, HOSA Canada

Abstract

Research question: Does neck strength influence head trauma in rear body-first falls?
Purpose of the research: Body-first falls are the most prevalent mechanism characterizing fall mechanics. There is very little know about the effect of body-first impacts on the risk of brain injuries. This study investigated the effect of body-first impacts in the rear direction on head impact dynamics.
Overall methods: A body-first drop protocol was developed to simulate an adult falling backwards at two different velocities (3.5 m/s and 5.0 m/s), two different neck stiffnesses (low and high), and two different rear falls (head-first vs body-first). A rear body-first fall is defined as falling backwards, first hitting one's back and then hitting the back of the head.
Major findings:
1. Linear acceleration was slightly lower for body-first impacts for both impact velocities and neck stiffnesses
2. Rotational acceleration increased for both neck stiffness when body-first impacts were compared for 3.5 m/s.
3. Rotational acceleration did not change when body-first impact was compared to direct impacts for the low-neck stiffness at 5.0 m/s impact velocity.

Conclusions: The data collected is preliminary but indicates a phenomena that should be further researched.

Methods

Target population: those at risk of falling
Drop Protocol Development:
- Developed to simulate an adult falling backwards
- Utilized a monorail drop system

Neck Stiffness Variation:
- Low and high neck stiffnesses created using springs to mimic specific neck muscles[1]
  - Extension springs = splenius capitis
  - Flexion springs = sternocleidomastoids
  - Lateral flexion springs = upper trapezius

Data Collection:
- Data collected using accelerometers which were filtered using a rear 180 filter
- Linear acceleration (g) and rotational acceleration (rad/s^2) calculated

Body-First Configuration Setup (Figure 1):
- 6.5cm offset chosen to represent average offset from back to back of head in adult males
- Back first contacts, then back of head

Direct Configuration Setup (Figure 2):
- Same configuration as body-first except no offset, so only the back of the head impacts

Impact Simulation:
- Head impacted hard flat anvil
- 24 Impacts:
  - 2 velocities (3.5 m/s, 5.0 m/s)
  - 2 neck stiffness (low, high)
  - 2 mechanisms (body-first and direct)
- 3 impacts for each condition

Data Analysis:
- Mean values for each condition documented in Figure 3, Figure 4, and Figure 5

Biases/limitation: mechanical neck is not a real neck - limits accuracy.

Figure 1: Body-first configuration

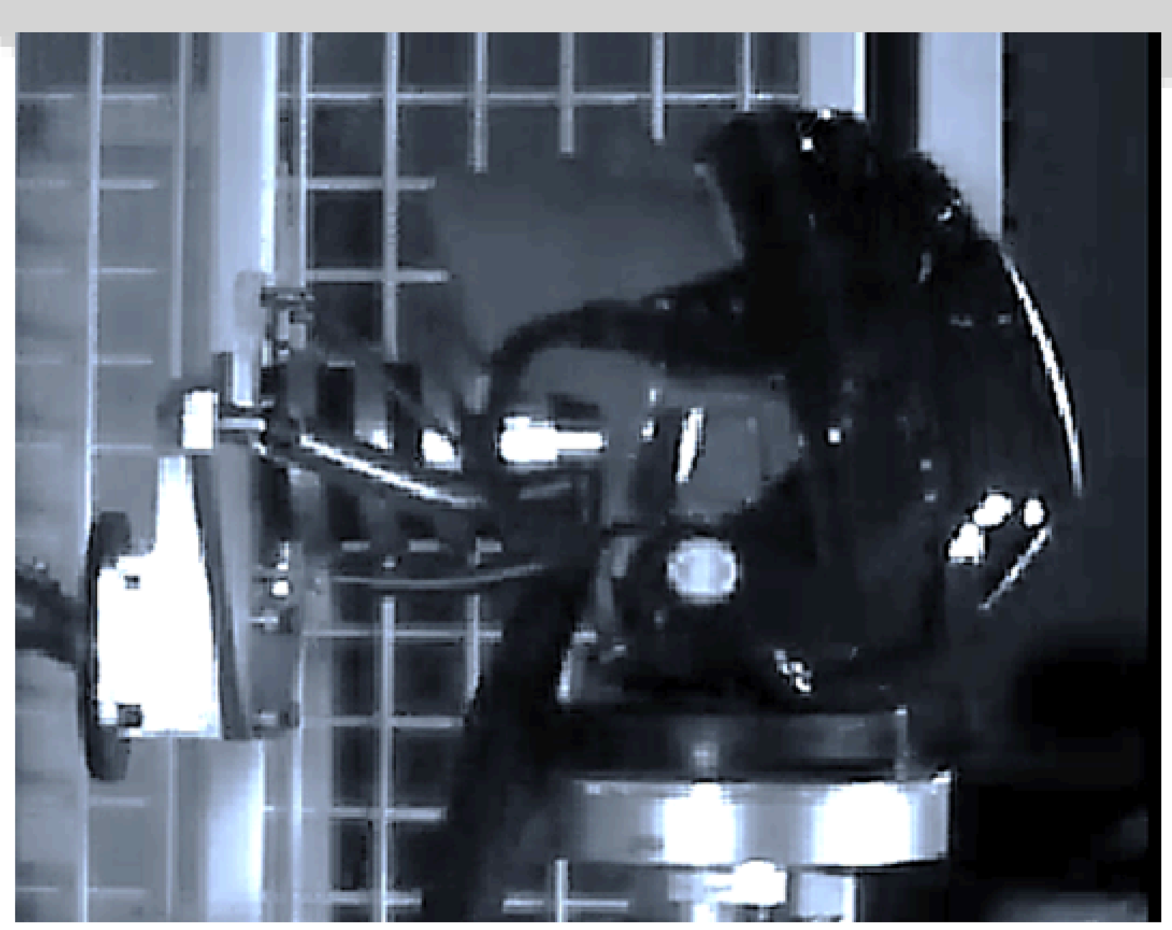

Figure 2: Direct configuration

Results

Rotational acceleration defines the severity of head trauma: high rotational acceleration = high risk of head trauma
1. Impact velocity had a significant effect on both linear and rotational acceleration for both neck stiffness except[2] the rotational acceleration for body-first impact for the low neck stiffness condition.
2. Neck stiffness had a minor effect on linear acceleration when compared across the two impact velocities and two impact types. There was a slight decrease in linear acceleration for both neck stiffness conditions.
3. Effect of neck stiffness on rotational acceleration:
   a. Increase in rotational acceleration for the body-first impacts at the 3.5 m/s impact for both neck stiffnesses.
   b. For the 5.0 m/s impacts there was no effect on rotational acceleration for the low-neck stiffness, however for the high neck stiffness the rotational acceleration of the head at impact increased dramatically.

Why these results matter: this data suggests that tensing neck muscles increases rotational acceleration in body-first falls, creating an increase in risk of head trauma

Figure 3: Mean linear and rotational acceleration values.

		Direct low neck stiffness (±SD)	Direct high neck stiffness (±SD)	Body-first low neck stiffness (±SD)	Body-first high neck stiffness (±SD)
3.5 m/s	Linear acc. (g)	101.7 (±0.96)	102.3 (±1.6)	95.3 (±2.99)	81.9 (±4.65)
	Rot. Acc. (rad/s^2)	9148 (±273)	10634 (±307.2)	15281 (±656.72)	16693 (±1261.56)
5.0 m/s	Linear acc. (g)	168.1 (±5.27)	168.4 (±0.75)	161.4 (±6.15)	150.5 (±3.04)
	Rot. Acc. (rad/s^2)	15469 (±2336.08)	15352 (±134.34)	14980 (±1526.84)	22597 (±377.86)

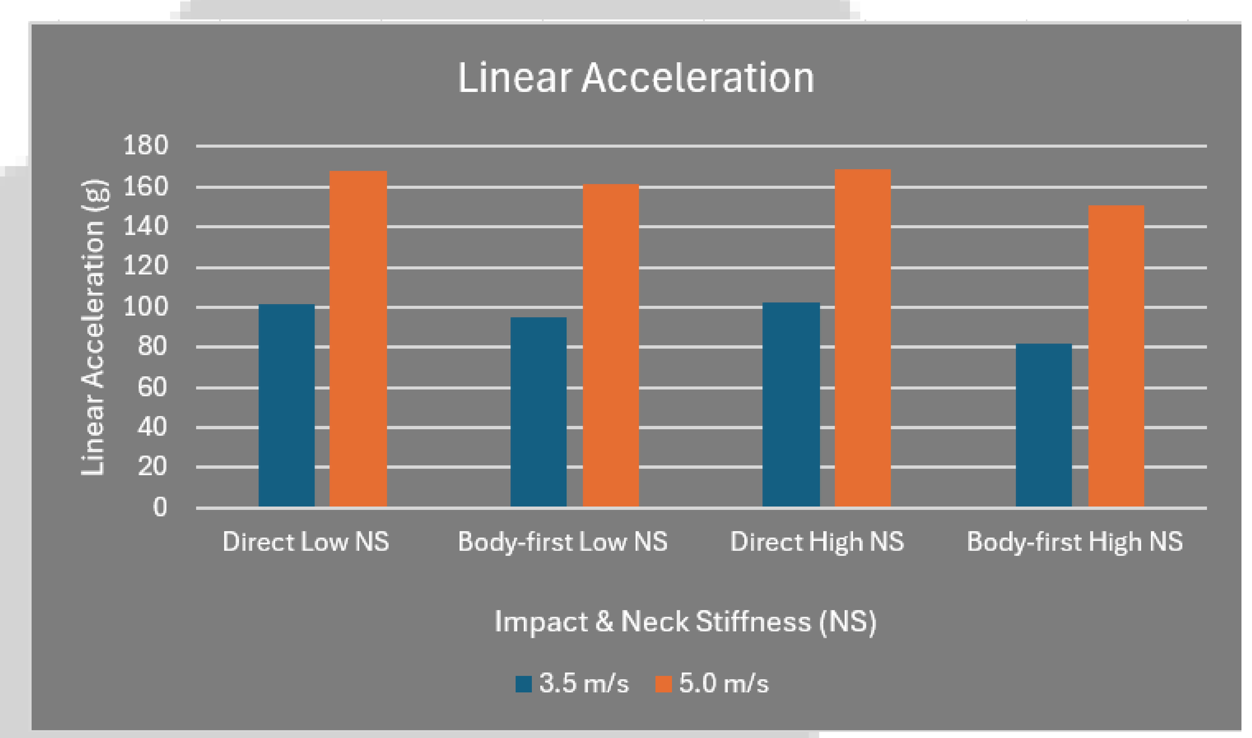

Figure 4: Mean linear acceleration values.

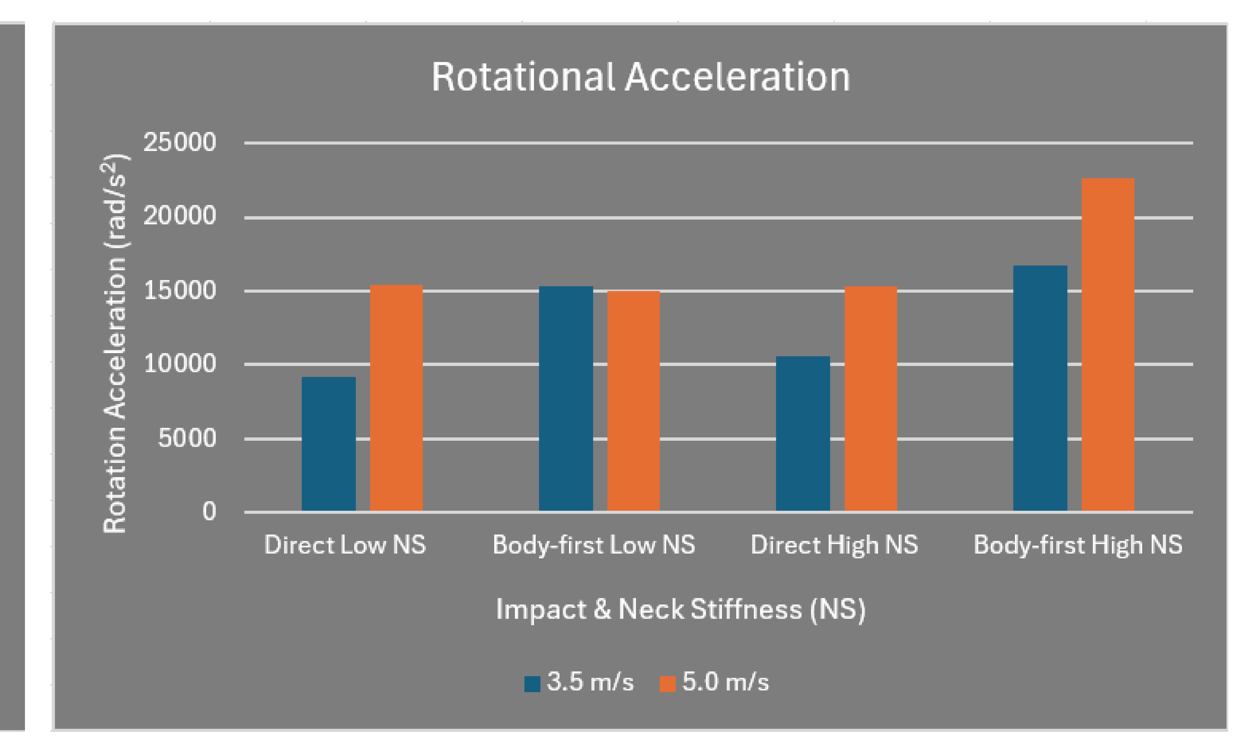

Figure 5: Mean rotational acceleration values.

Conclusions

The data suggests tensing neck muscles during a body-first fall can potentially increase the risk of brain trauma. The findings from this research provide insights that can be used to guide the development of interventions to decrease rotational acceleration in body-first impacts leading to a decrease in the risk of brain injuries in body-first falls. These results are preliminary but impact anyone that is at risk of falling.

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References

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