

# SAFE Europe

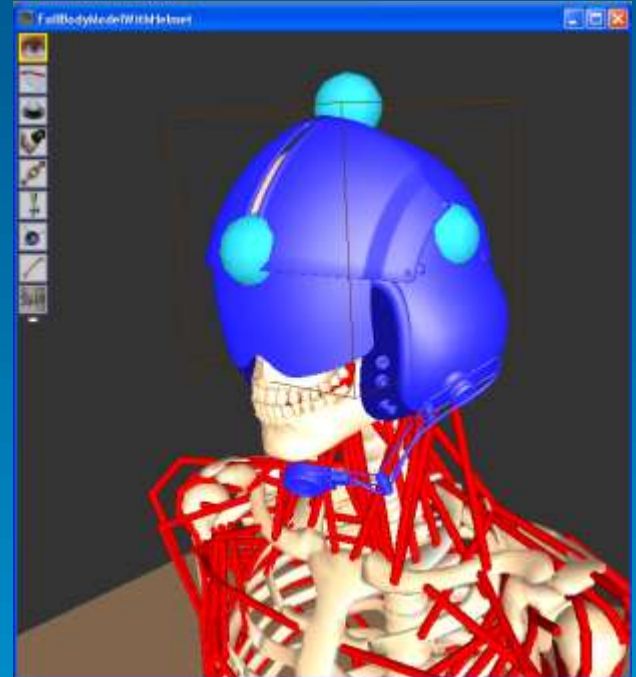
## Modelling the impact of head-worn mass on neck and muscle parameters

MGA Llewellyn, KPM Puxley, KE Phillips and JA Storey

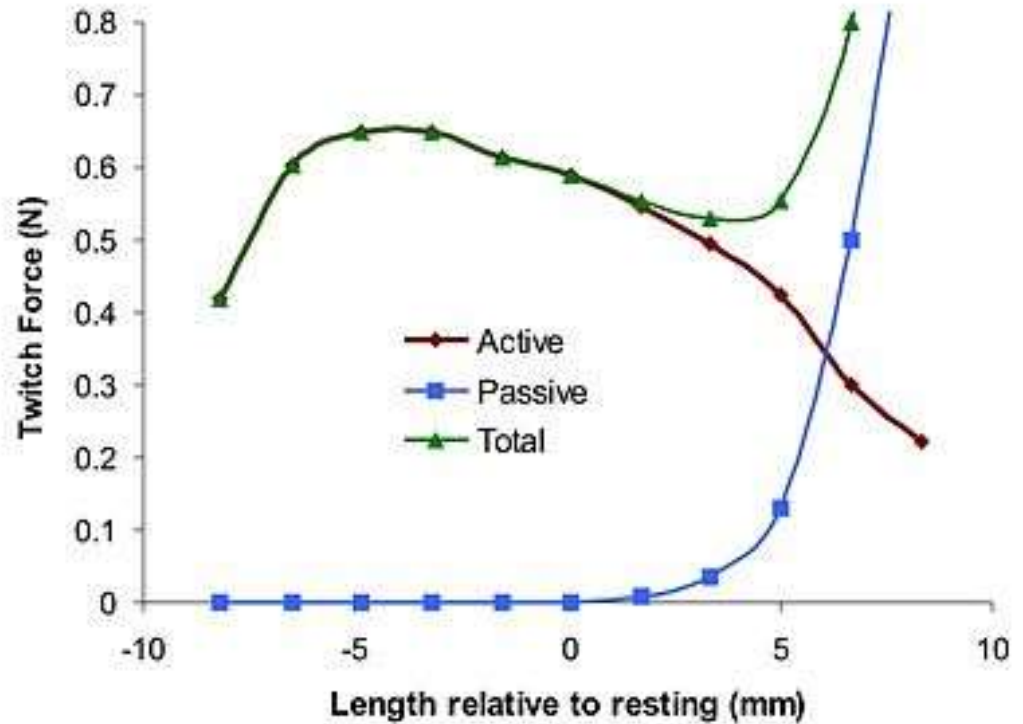
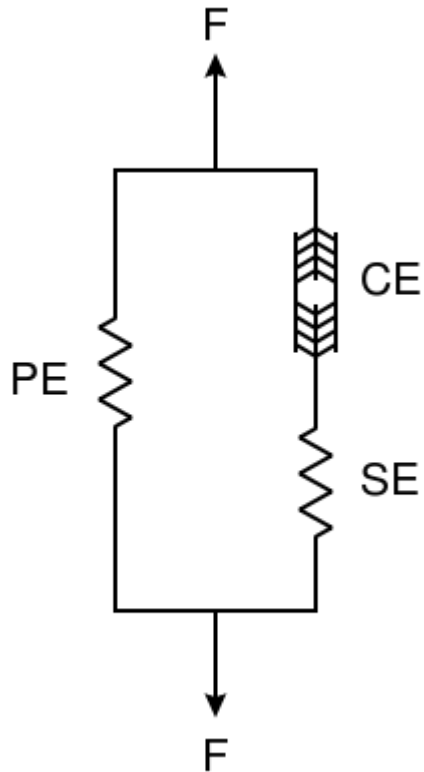
Aircrew Systems, QinetiQ Ltd

April 2016

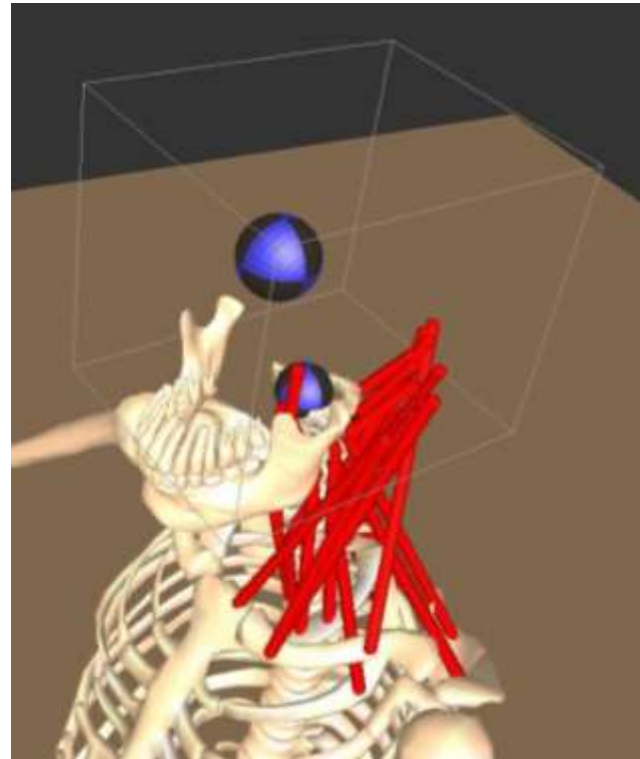
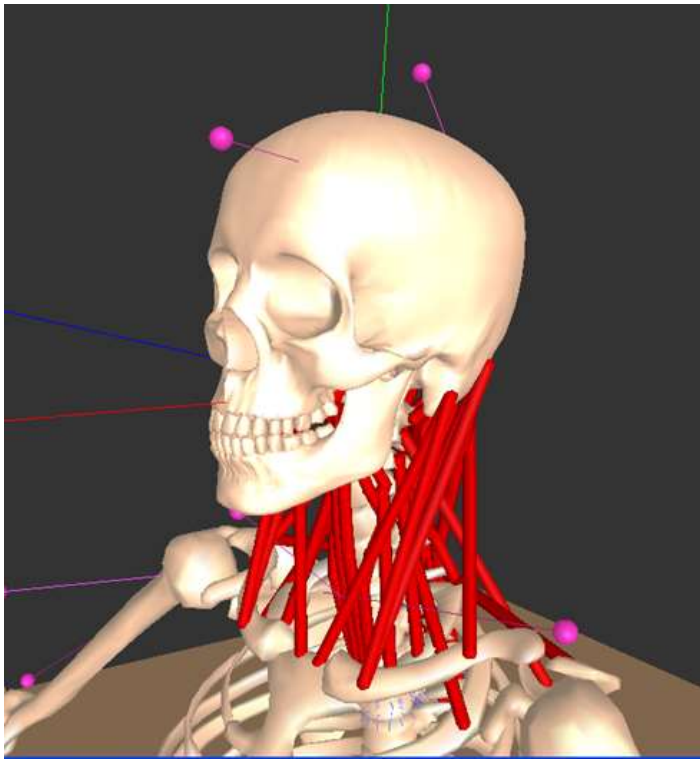
QinetiQ/16/00912



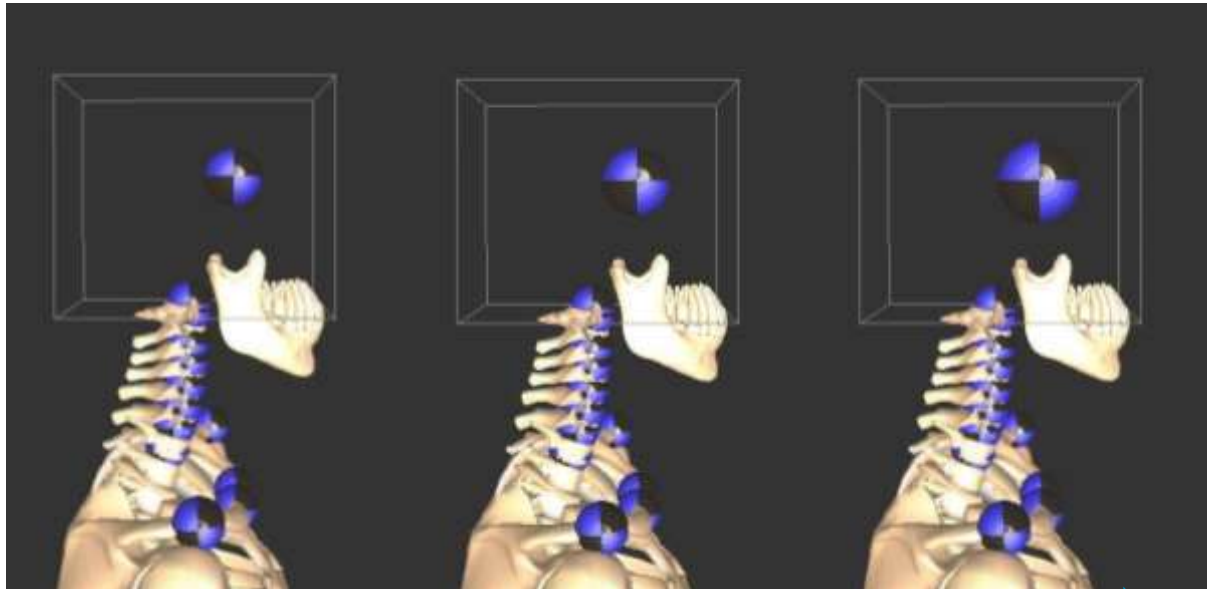
# Hill Muscle Model



# Software for Interactive Musculoskeletal Modelling (SIMM) - Modifications to the model

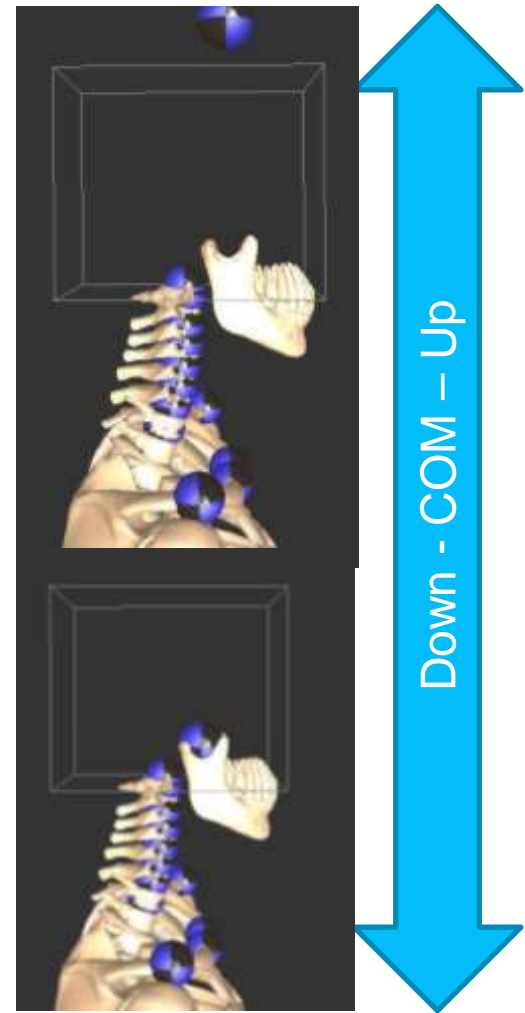
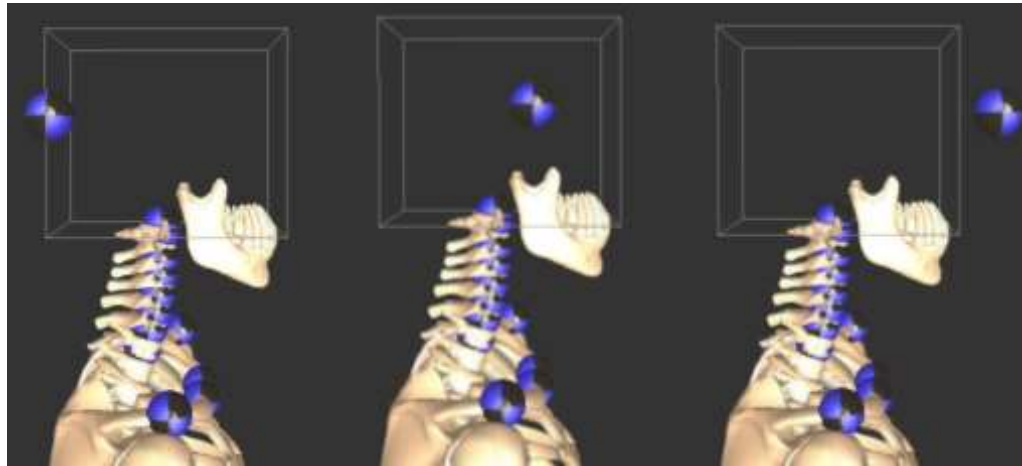


# Changing Head Mass without moving COM position

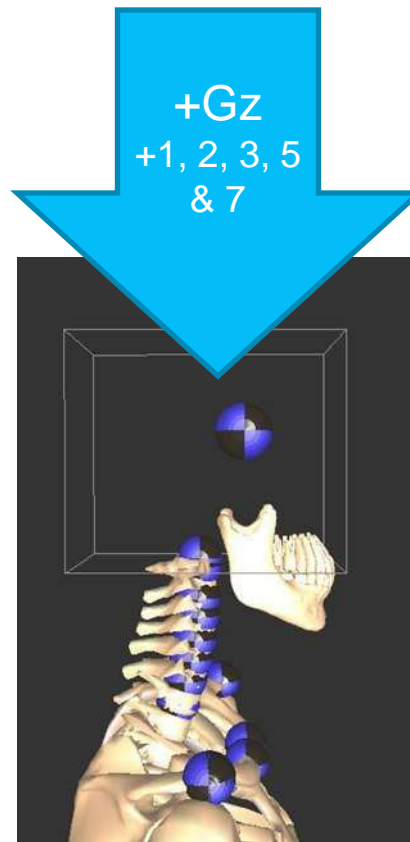


Naked head (4.005kg) to Head + 5kg

# Changing COM Position without changing Head Mass



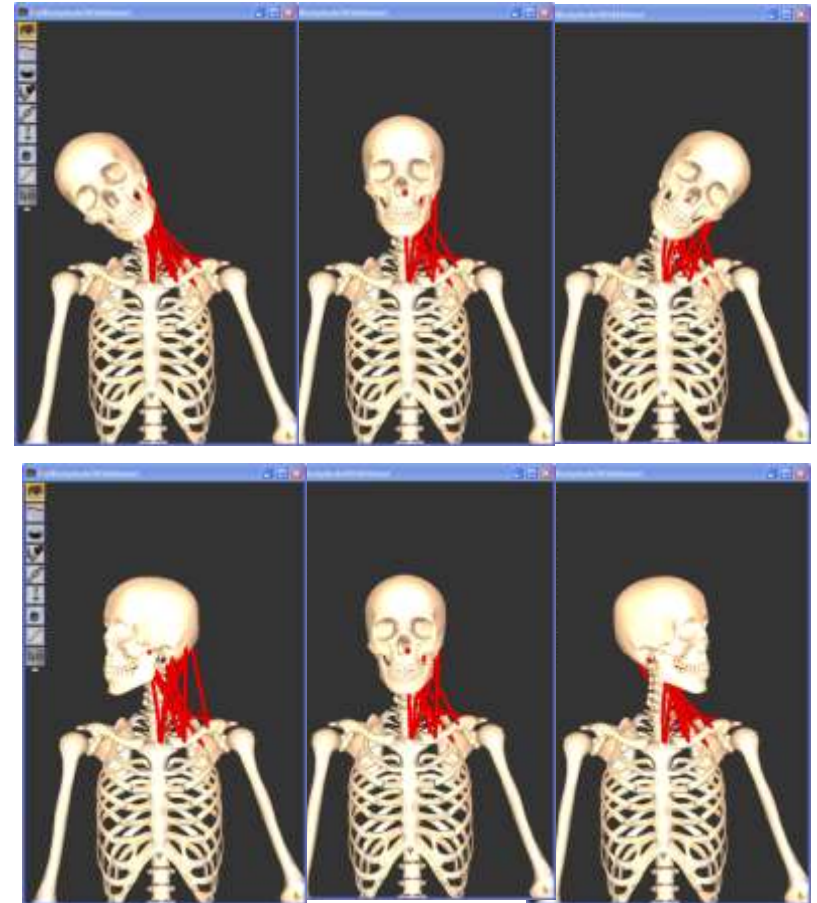
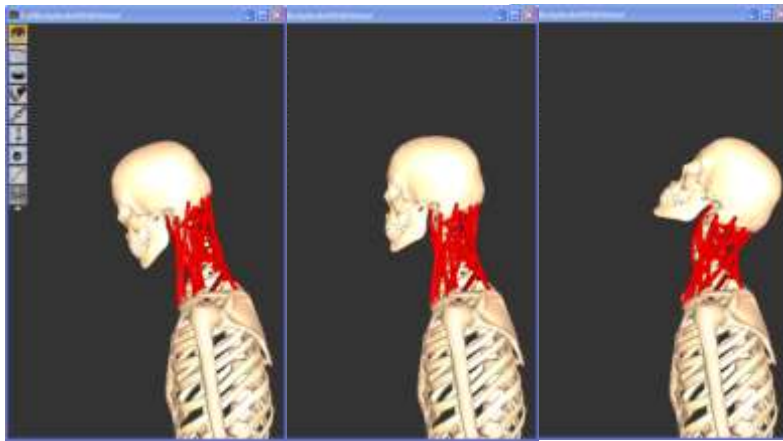
# Changing +Gz without changing Head Mass or COM position



Head Mass  
4.005kg

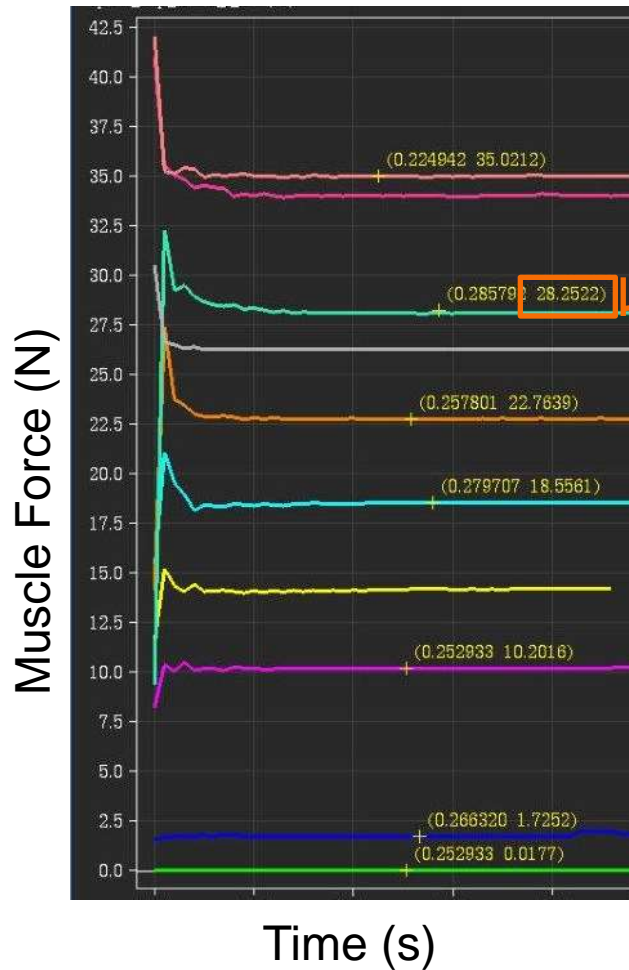
# Inputs

Neck Roll, Pitch & Yaw  
10 degree increments





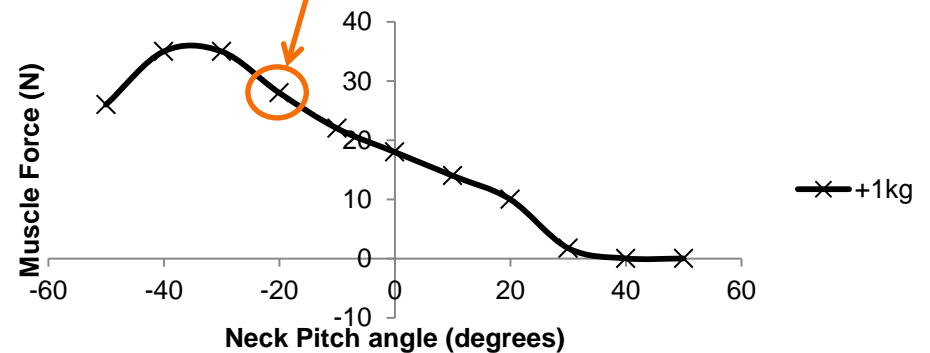
# Transcribing Model Output



## Splenius capitis sklc6

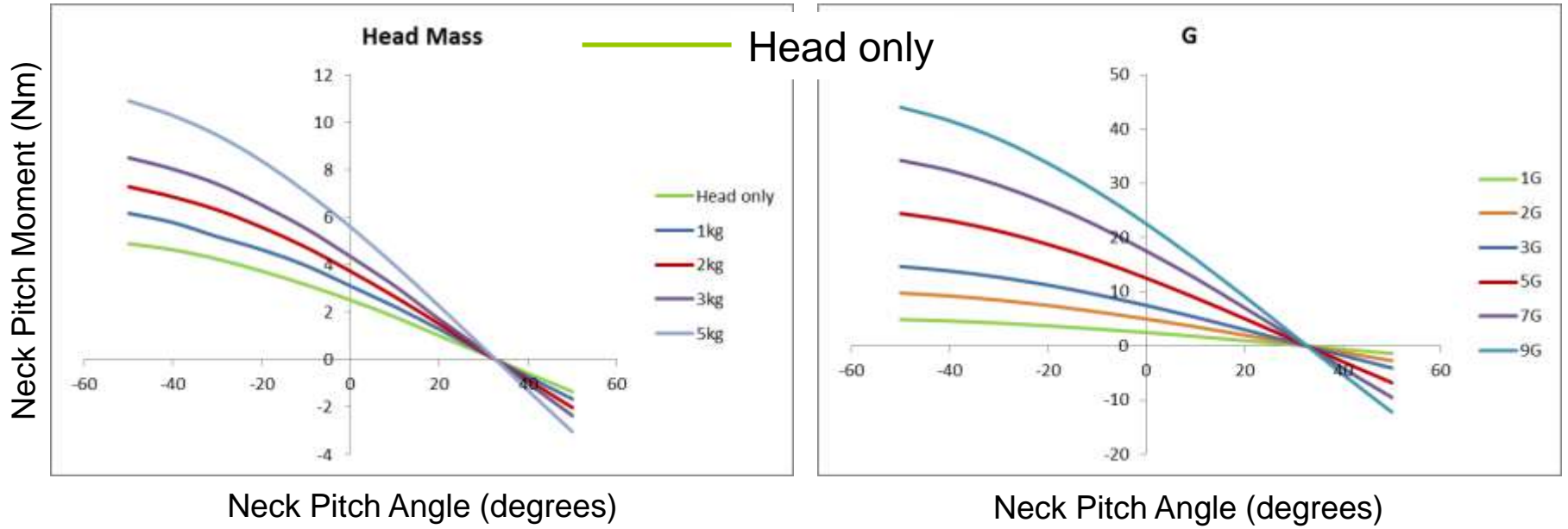
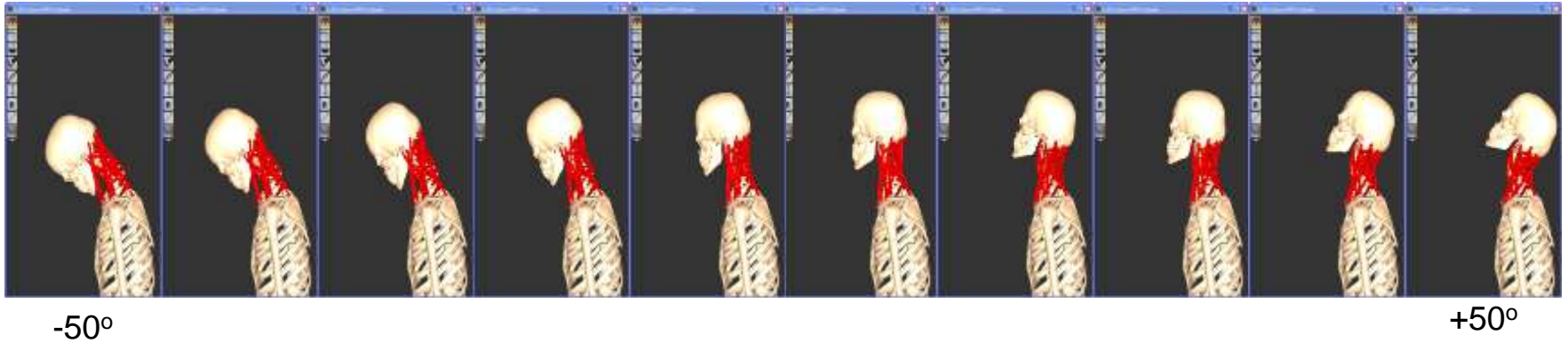
PITCH	Angle	4.005 Kg	Head	Head	Head	Muscle L/T
		Head only	+1kg	+2kg	+3kg	
FLEXION	-50	17.7	26	34	34	36
	-40	25	35	37	37	39
	-30	26	35	40	41	42
	-20	23	28	33	42.1	43
	-10	19	22	26	30	43
EXTENSION	0	15.8	18	21	23	42
	10	12	14	16	18	40
	20	9	10	11	12.85	38
	30	1.2	1.77	2.4	2.95	32
	40	0.03	0.03	0.03	0.03	23
	50	0.01	0.018	0.02	0.018	6

### I. Splenius capitis Force vs. Neck Pitch angle

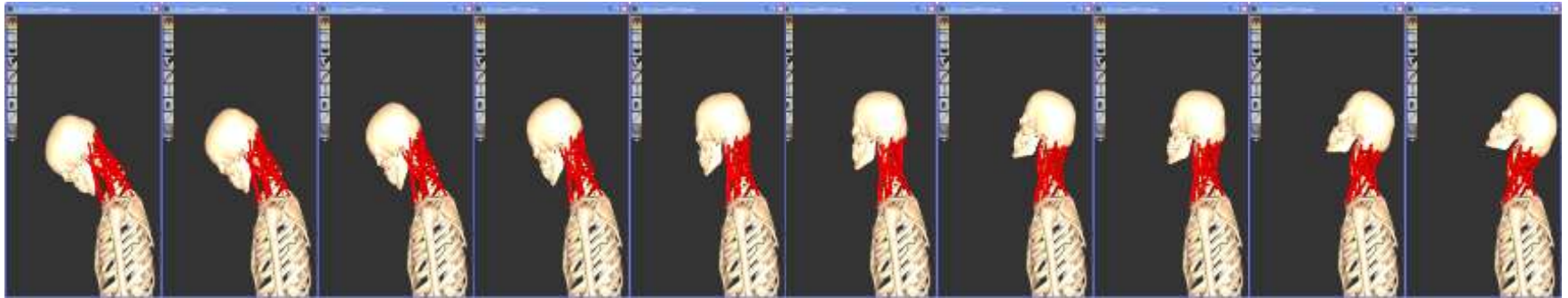




# Neck Pitch Moment (Nm) - Increased MASS and +Gz

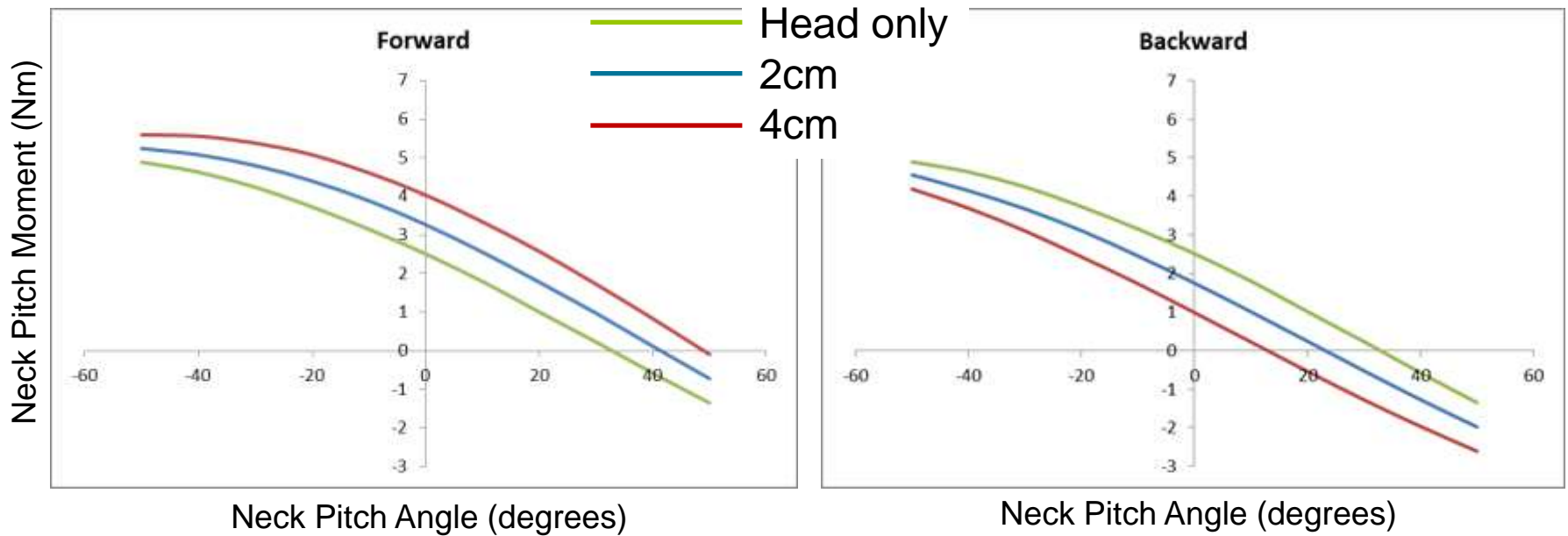


# Neck Pitch Moment (Nm)– COM Forward / Backward



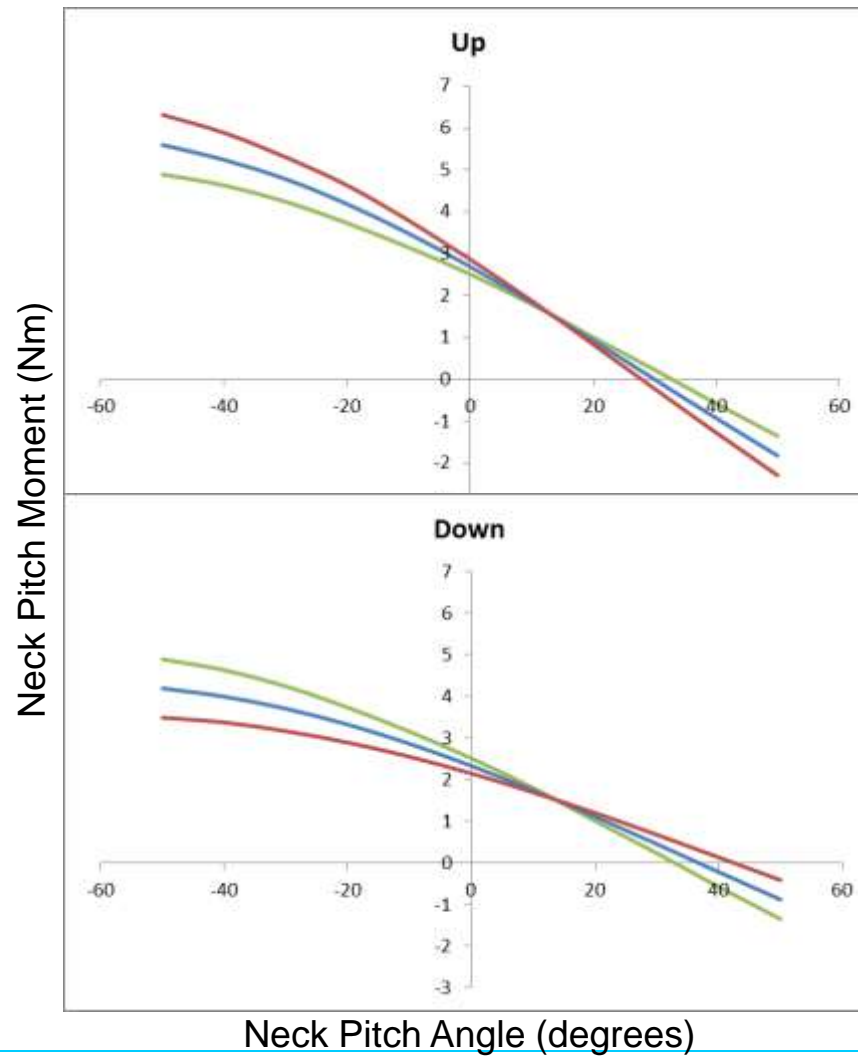
-50°

+50°

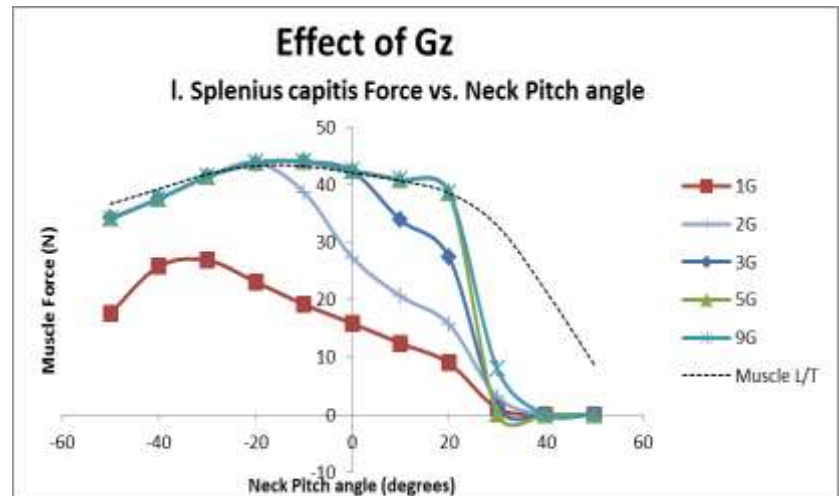
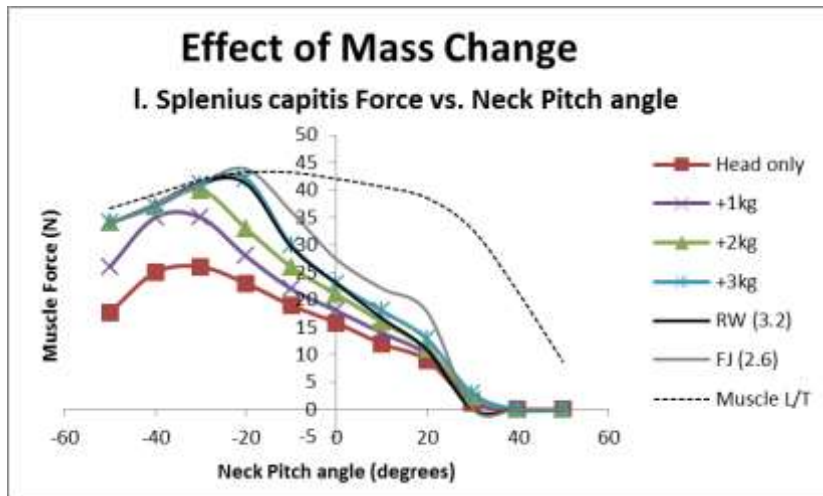


# Neck Pitch Moment (Nm) –COM Up / Down

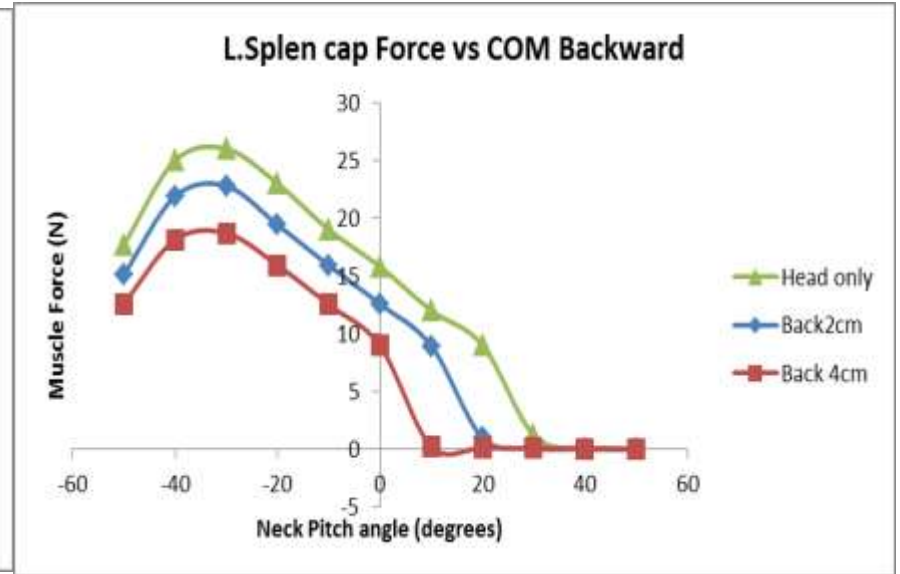
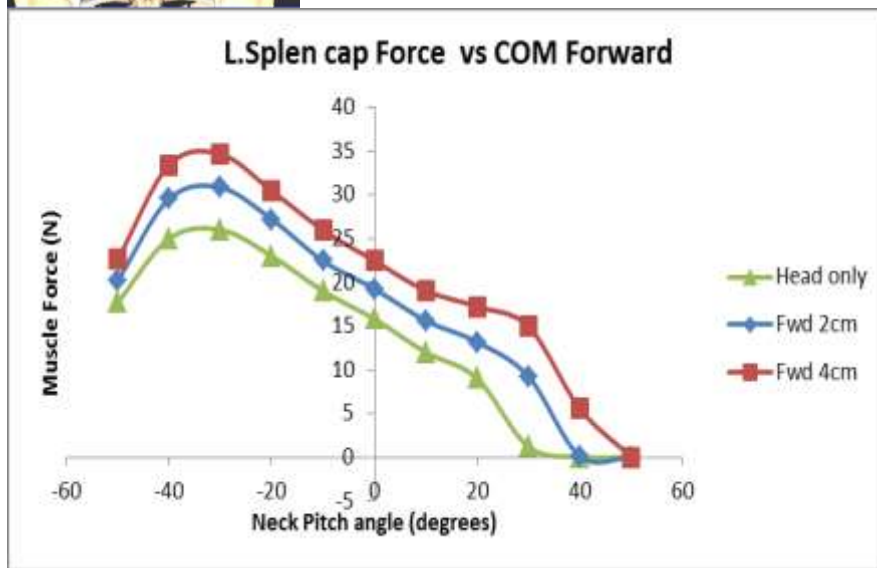
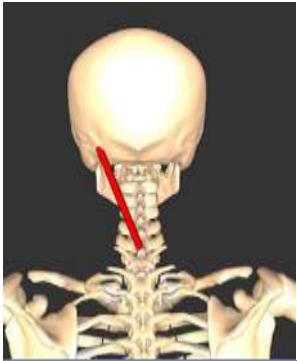
- Head only
- 2cm
- 4cm



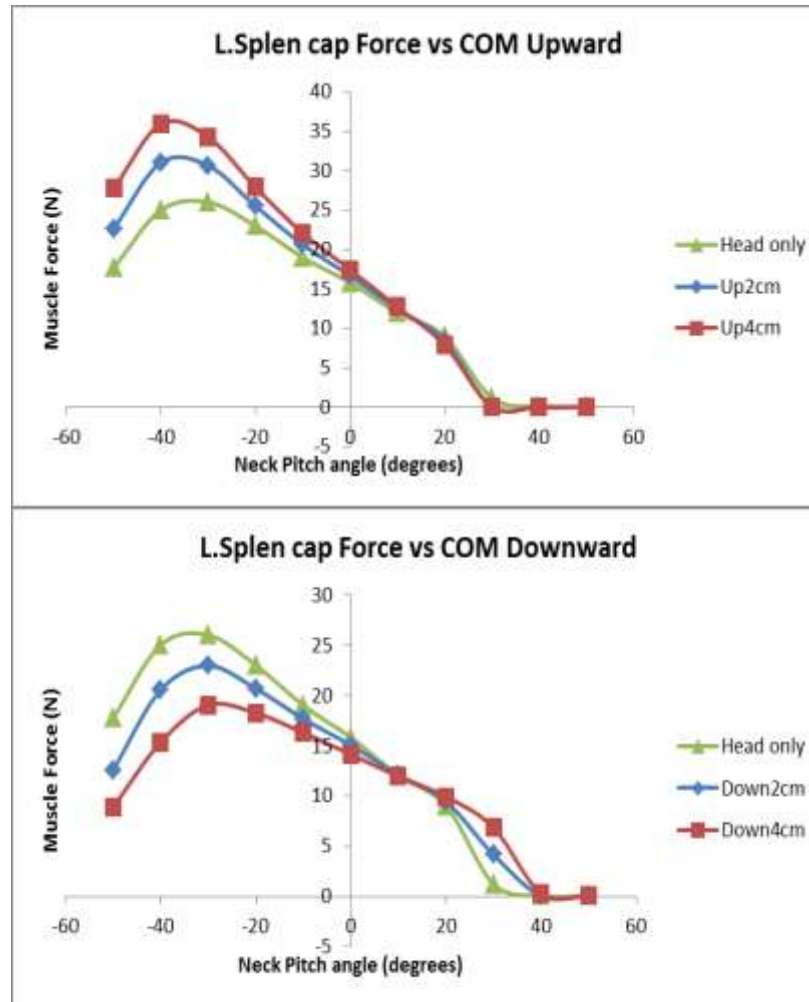
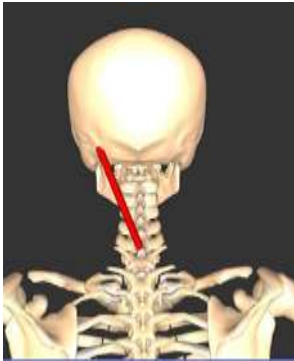
# Muscle Force (N) (Neck Pitch) – Increased Mass and G



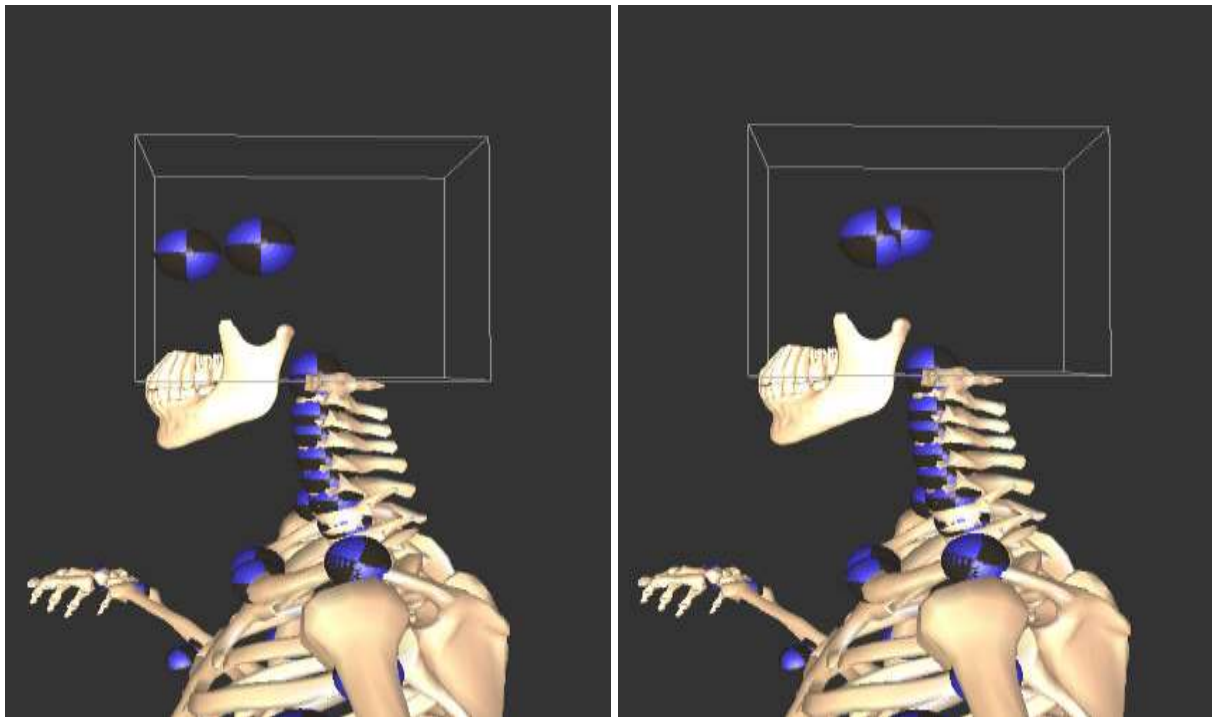
# Muscle Force (N) (Neck Pitch) - COM Forward / Backward



# Muscle Force (N) (Neck Pitch) - COM Up / Down



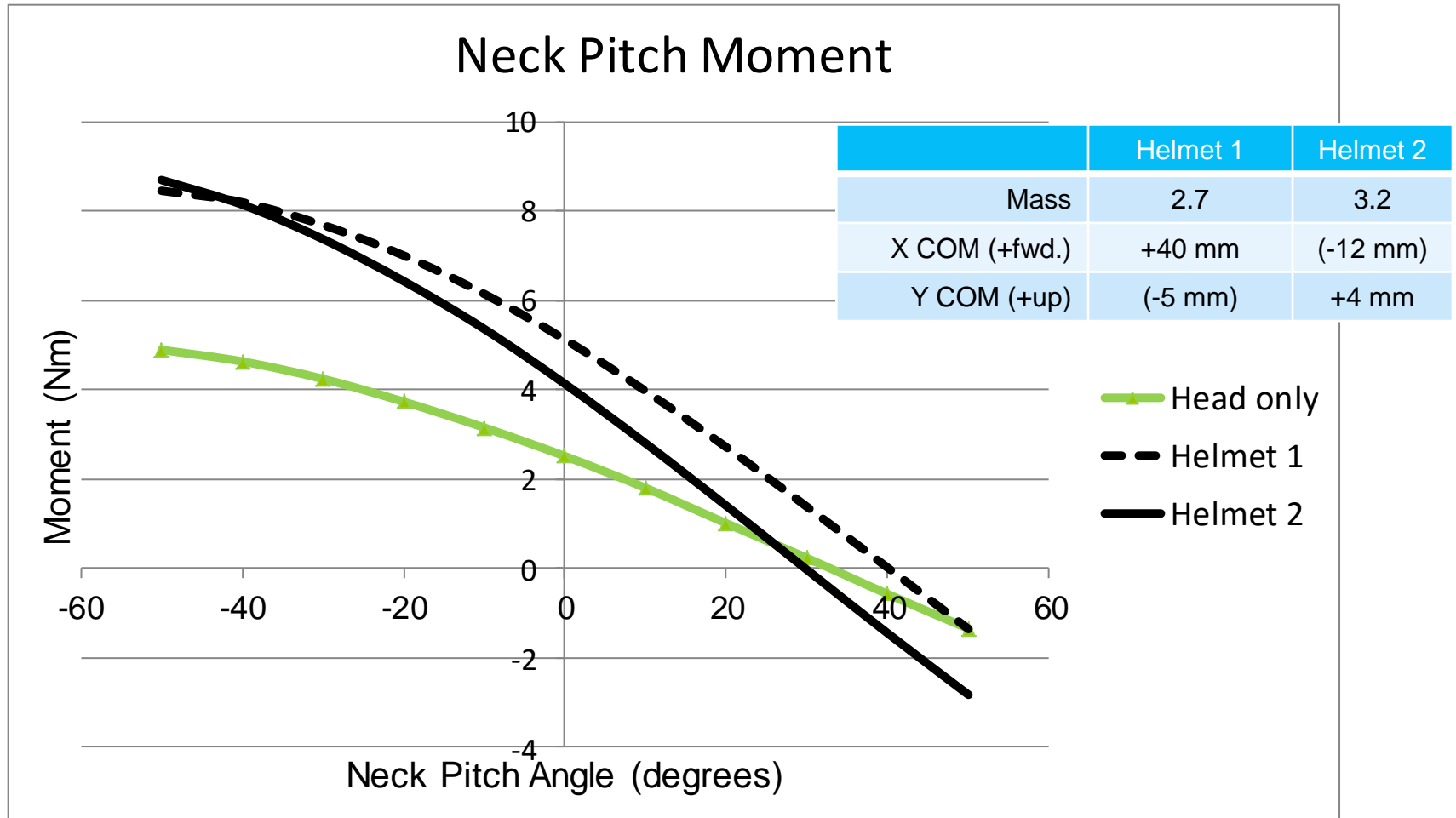
# Application – A) Comparing helmets / concepts



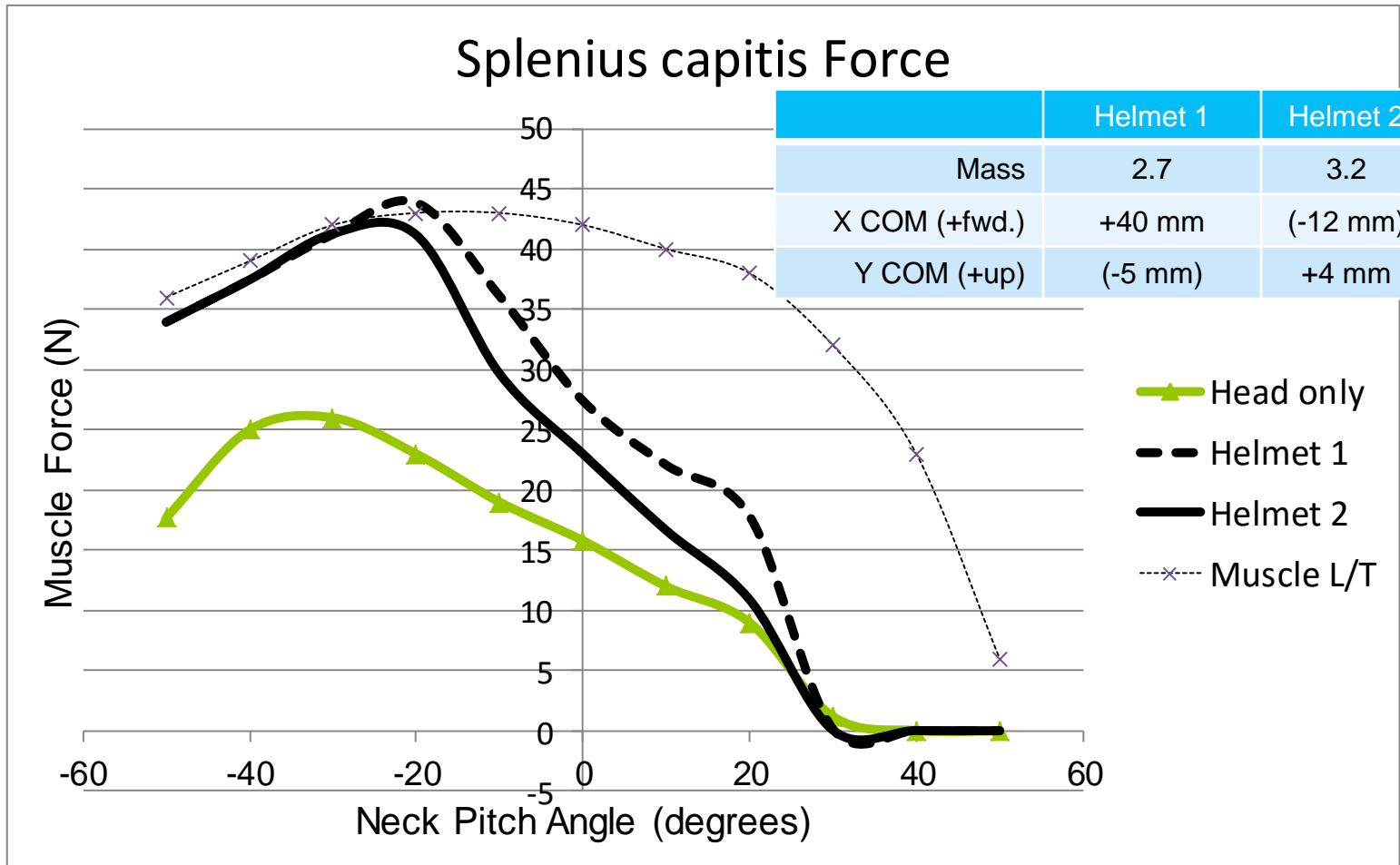
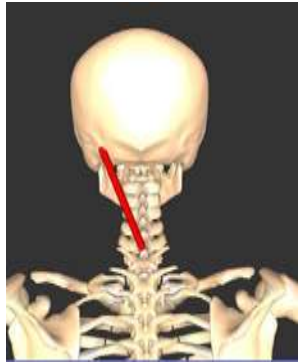
	Helmet 1	Helmet 2
Mass	2.7	3.2
X COM (+fwd.)	+40 mm	(-12 mm)
Y COM (+up)	(-5 mm)	+4 mm



# Application – A) Comparing helmets / concepts



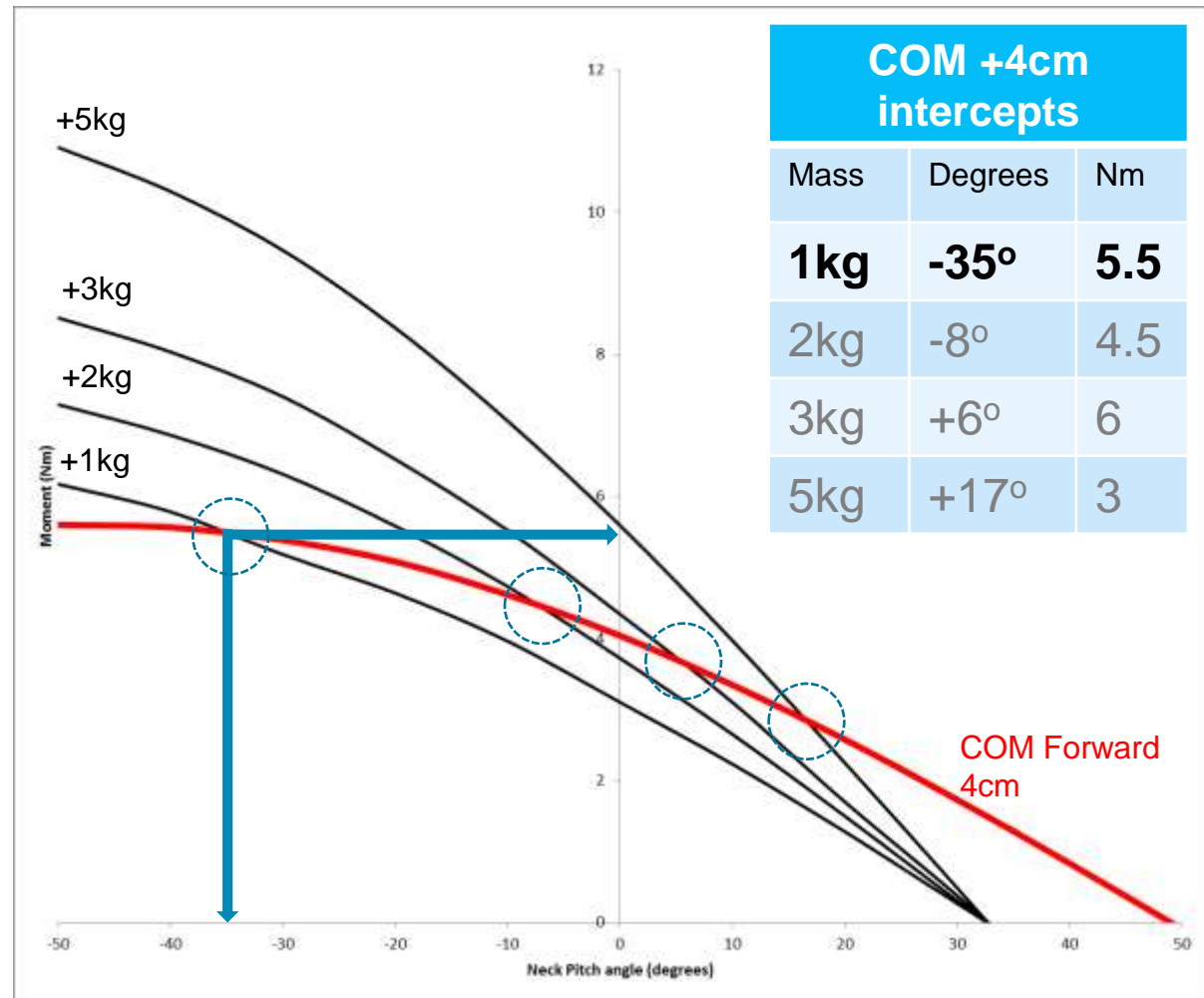
# Application – A) Comparing helmets / concepts



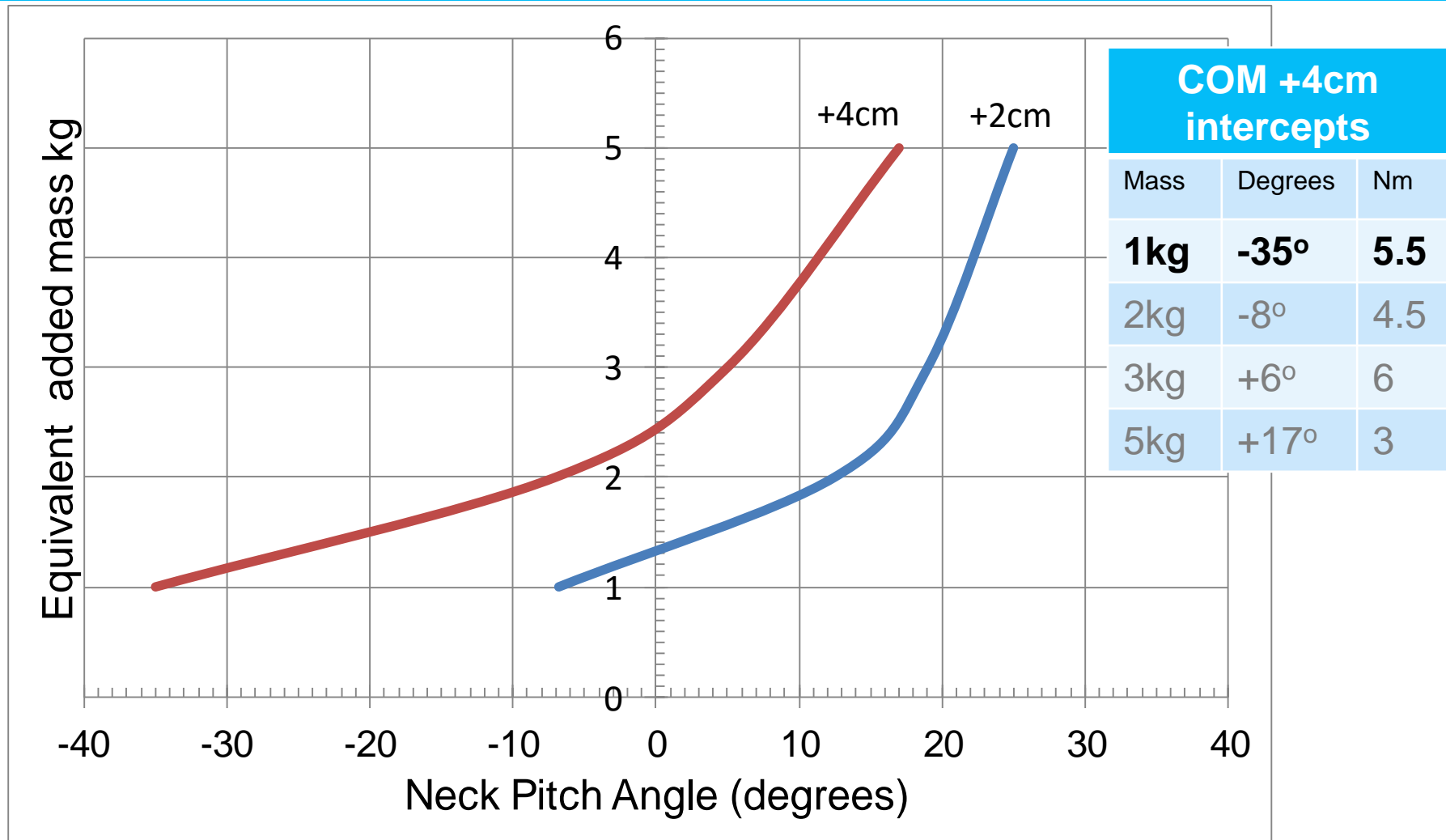
# Application – B) How does moving COM position equate to added Mass?

Black lines  
Neck moment due to  
mass increases  
(+1,+2,+3 & +5kg)

Red line  
Neck moment due to  
COM position change  
(Fwd. +4cm)

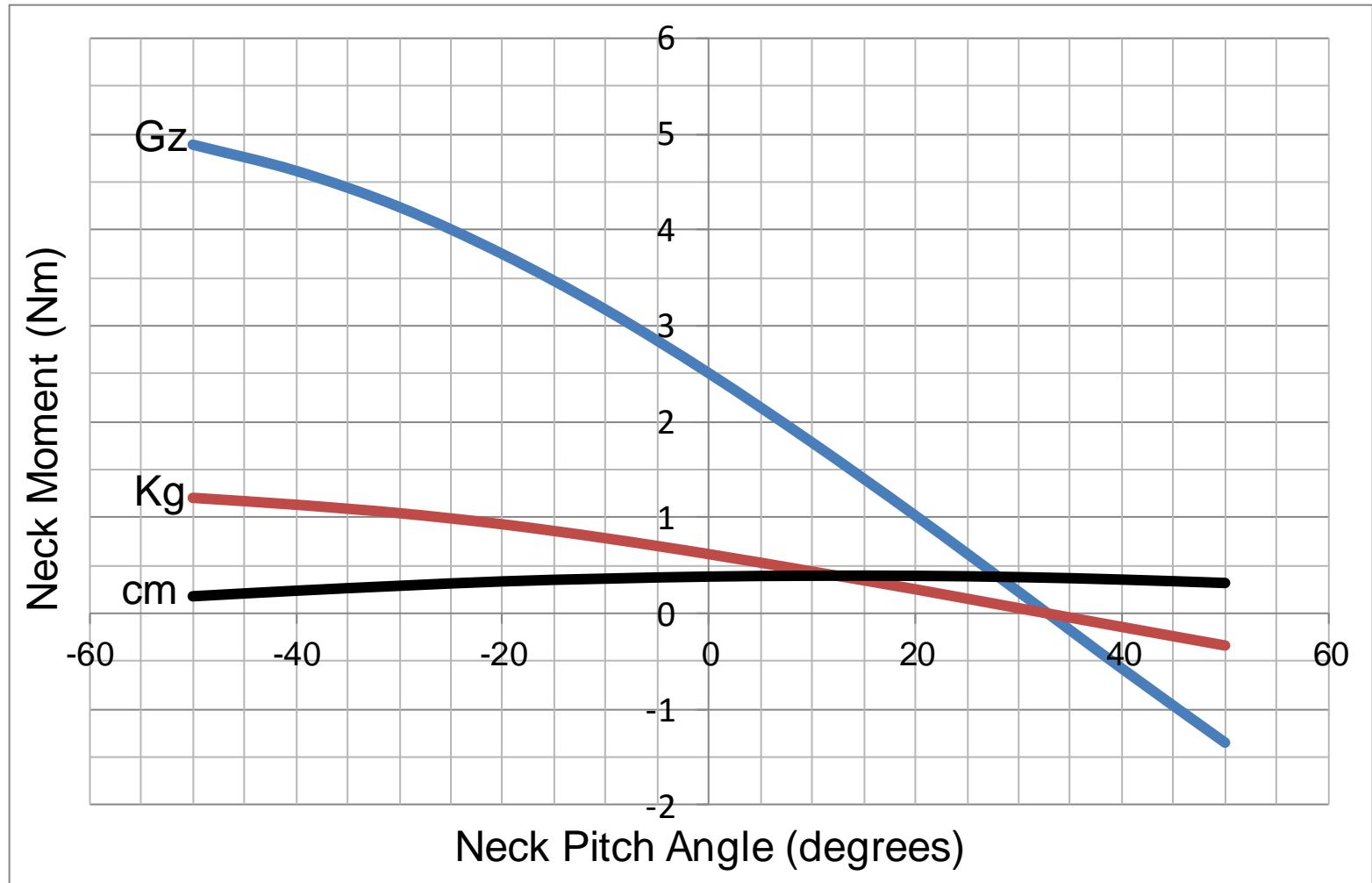


# Application – B) How does moving COM position equate to added Mass?



# Application – C) Link to role

## Sensitivity to Gz, Mass and COM offset (forward / backward)



# On-going

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1. Complete  
Roll and Yaw movements  
All muscle (26 in total) variables for Roll, Pitch and Yaw
2. More realistic compound movements (e.g. 'check-six) using motion capture data.
3. Effects of combining mass, moment and G (additive, or some multiple function).
4. Relationship between muscle response and added mass, moment or G

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# Thank-You