BoB Biomechanics of Bodies

Case Studies

Vehicle ingress/egress

The biomechanics group at Coventry University undertook an analysis of base and modified vehicles' ingress and egress for General Motors using BoB.

Seven subjects were selected to maximise the variation in anthropometric metrics within the sample. To measure the movements of each of the major segments of the body, the subjects wore a magneto-inertial motion capture suit.

All of the subjects were instructed to ingress and egress the trial vehicles. The subjects were instructed to:

- Walk to the vehicle through a distance of approximately 4m
- Open the door
- Enter the vehicle and sit in the rear seat
- Close the door
- Relax in the rear seat for a duration of approximately 2s
- Open the door
- Egress the vehicle
- Close the door
- Walk to the approximate starting position

Joint angles were calculated from the motion captured data. Joint articulations and loads in the muscles were calculated using BoB.

The loads in the muscles of the back were calculated using an optimisation procedure.

Results

Major joint articulation angles were recorded for all of the subjects during ingress and egress for the trial vehicles. Table 1 shows the change in the angles of articulation in the back between the base and modified vehicles. Table 2 shows the calculated changes to the loads in the back muscles between the base and modified vehicles.

Back Angles

	Base vehicle			New vehicle			Change		
	Lean	Bow	Twist	Lean	Bow	Twist	Lean	Bow	Twist
Bag in	28°	41°	16°	21°	44°	15°	-27°	7°	-6°
Bag out	23°	45°	40°	18°	46°	21°	-22°	1°	-48°
Entry	73°	62°	57°	42°	67°	33°	-43°	8°	-43°
Egress	38°	62°	45°	37°	52°	37°	-3°	-17°	-17°

Table 1:
Back articulation angles

Muscle Loads

	Base vehicle		New vehicle		Change	
	Erector spinae	Rhomboid major	Erector spinae	Rhomboid major	Erector spinae	Rhomboid major
Bag in	2071N	1025N	1710N	750N	-17%	-27%
Bag out	1873N	1761N	1567N	731N	-16%	-58%
Entry	1974N	1058N	1407N	943N	-29%	-11%
Egress	1562N	1218N	1392N	887N	-11%	-27%

Table 2:
Loads in selected back muscles

Conclusions

The results from the BoB analysis enabled the quantification of the joint articulations and muscle loadings. These results were compared with the results from a parallel study which recorded the user comfort levels whilst entering and exiting the vehicles.

Further studies will be undertaken to establish a correlation between biomechanical metrics and vehicle comfort levels.

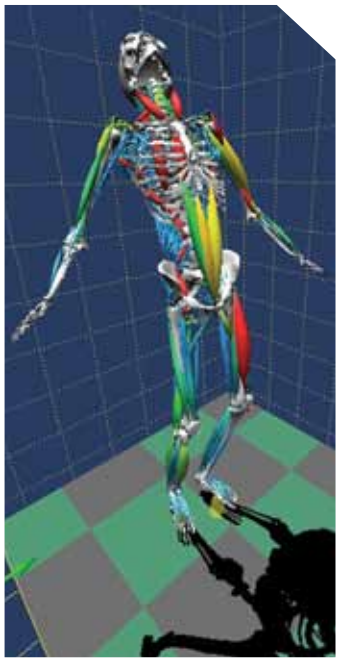
BoB Biomechanics of Bodies

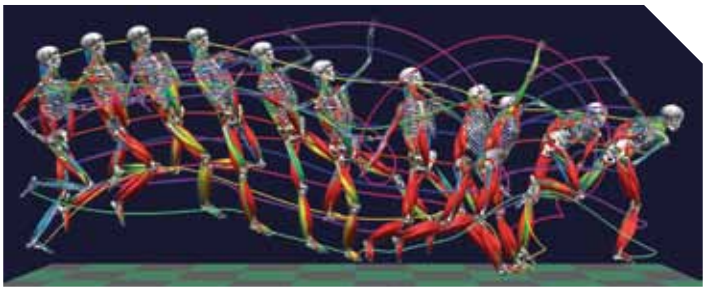
Case Studies

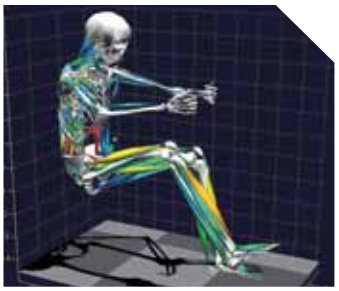
Spinal cord injury

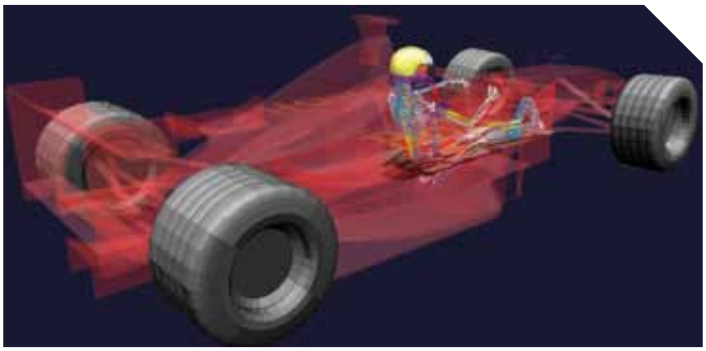
Post spinal cord injury, bone demineralisation occurs in the skeleton distal to the lesion level due to the absence of daily occurring stress levels in excess of the osteogenic threshold. This results in bones which can be fractured during routine daily activities, for example, the transfer from a bed to a wheelchair.

In an attempt to reduce the bone demineralisation, subjects undertake a regime of exercise on a laboratory based rowing machine whilst some leg muscles are activated using functional electrical stimulation. However, care must be taken to ensure that the stress in the leg bones do not exceed their fracture threshold in their partially demineralised state. A research project used BoB to calculate the loads in the femurs to ensure that the forces were within the envelope defined by the osteogenic threshold and fracture threshold throughout the rowing cycle.









Publications

Gibbons R, McCarthy I,Gall A, Stock C, Shippen J, Andrews B
Can 4-channel FES-rowing mediate bone mineral density in SCI: a pilot study
Spinal Cord 2014

Copaci DS, Rojas DB, Shippen JM, Caballero AF, Lorente LM, May B
Complex environment simulation for rehabilitation of the elbow
Submitted to IEEE Transactions on Neural Systems & Rehabilitation Engineering.

Wagner DW, Stepanyan V, Shippen JM, DeMers MS, Gibbons RS, Andrews BJ, Creasey GH, Beaupre GS
Consistency Amongst Musculoskeletal Models: Caveat Utilitor
Annals of Biomedical Engineering 2013 Aug;41(8):1787-99. doi: 10.1007/s10439-013-0843-1. Epub 2013 Jun 18.

Shippen JM, May B
The calculation of ground reaction forces during dance in the absence of forceplates
Journal of Dance Science and Medicine , Vol 16 Number 1, 2012

Shippen JM, May B
Calculation of Muscle Loading and Joint Contact Forces in Irish Dance Journal of Dance Science and Medicine, Volume 14 1 pp11-18 2010

Unit 10 Rugby Park | Bletchley Road | Heaton Mersey | Stockport | SK4 3EJ UK
Tel: (+44) (0) 161 947 9113 | Fax: (+44) (0) 161 947 9099 | www.prosim.co.uk