**APPENDIX**

**Model Settling Procedure:**

Prior to carrying out the frontal low-speed acceleration pulse validation simulations, the leg angles were adjusted through gravity settling. Therefore, the feet would subsequently land on the right foot pedal and left support plate, matching experimental angles as closely as possible. For these settling simulations, all muscles are inactive and the model was set approximately 50 mm above the seat at time zero. The model was then allowed to fall on the seat due to an applied body force equal to gravity. The nodal coordinates along with joint angles were extracted at a time when good contact between the model and the seat was observed.

**Implementation in LS-DYNA:**

The PID controller was modeled in LS-DYNA using PIDCTL function. A function was defined using \*DEFINE\_FUNCTION to calculate muscle activation for each muscle using Eq. (1). Joint angle measurement was also carried out using \*DEFINE\_FUNCTION and \*DEFINE\_CURVE\_FUNCTION. The method of joint angle calculation utilized two coordinate systems is explained in the literature (Kato, et al. 2017). The Hill-type muscle material model was defined in LS-DYNA using \*MAT\_MUSCLE. \*PART\_AVERAGED keyword was used to model some muscles to simulate the muscle path as cable.

**Effect of PID Controller Gain:**

The proportional term is directly related to the controller output, so higher proportional gain leads to larger controller output. The integral term accumulates the error term from the past and thus may cause overshoot and instability in the controller output. While the derivative term uses the slope of the error over time, it predicts system behavior, helps in stabilizing the controller output, and reduce settling time.

Table A1. Percentage Contribution and PCSA of Neck Muscles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Muscle | PCSA  (mm2) | Head-Neck Joint (Left) | | |
| Left Lateral Flexion | Flexion | Left Rotation |
| Anterior Scalene | 187.301 | 0.55 | 0.42 | 0.03 |
| Middle Scalene | 136.164 | 0.55 | 0.42 | 0.03 |
| Posterior Scalene | 70.35 | 0.55 | 0.42 | 0.03 |
| Iliocostlis | 83.050 | 0.19 | -0.78 | 0.03 |
| Inferior Oblique Capitis | 195.1 | 0.3 | -0.35 | 0.35 |
| Longissimus Capitis | 98.698 | 0.24 | -0.7 | -0.06 |
| Longissimus Cervicis | 149.2 | 0.17 | -0.82 | -0.01 |
| Longus Capitis | 137.1 | 0.69 | -0.22 | -0.09 |
| Major Posterior Rectus Capitis | 164.7 | 0.15 | -0.64 | -0.21 |
| Minor Posterior Rectus Capitis | 94.5 | 0.15 | -0.64 | -0.21 |
| Omohyoid | 78.2 |  | 1 |  |
| Semispinalis Cervicis | 305.802 | 0.05 | -0.93 | 0.02 |
| Splenius Cervicis | 142.258 | 0.17 | -0.74 | -0.09 |
| Sternocleidomastoid | 483.1 | 0.49 | 0.2 | -0.31 |
| Sternohyoid | 60.3 |  | 1 |  |
| Sternothyroid | 68 |  | 1 |  |
| Superior Oblique Capitis | 88.90 | 0.12 | -0.58 | 0.3 |

Table A2. Percentage Contribution and PCSA of Thorax and Abdomen Muscles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Muscle | PCSA  (mm2) | Thorax-to-Pelvis (Left) | | |
| Left Lateral Flexion | Flexion | Left Rotation |
| Rectus Abdominis | 1050 |  | 1 |  |
| External Oblique | 1027.56 | 0.25 | 0.2 | 0.55 |
| Internal Oblique | 597.98 | 0.24 | 0.46 | -0.3 |
| Transversus Abdominis | 2337.5 |  |  | -1 |
| Quadratus Lumborum | 280 | 1 |  |  |
| Ilicostalis Lumborum | 600 | 0.33 | -0.6 | -0.07 |
| Erector Spinae | 1638 | 0.17 | -0.77 | -0.06 |

Table A3. Percentage Contribution and PCSA of Scapulo-Thoracic Muscles

|  |  |  |  |
| --- | --- | --- | --- |
| Muscle | PCSA  (mm2) | Thorax-to-Pelvis (Left) | |
| Depression | Adduction |
| Trapezius Upper | 317.64 | 0.65 | 0.35 |
| Trapezius Middle | 444.69 |  | 1 |
| Trapezius Lower | 508.22 | 0.65 | 0.35 |
| Levator Scapula | 296.494 | 1 |  |
| Rhomboid Major | 136.278 | 0.61 | 0.39 |
| Rhomboid Minor | 76.972 | 0.61 | 0.39 |
| Serratus Anterior | 1393 | -0.65 | -0.35 |
| Pectoralis Minor | 374 | 0.61 | -0.39 |
| Subclavious | 42 | 0.61 | -0.39 |

Table A4. Percentage Contribution and PCSA of Upper Extremity Muscles

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Muscle | PCSA  (mm2) | Shoulder-Joint | | | Elbow Joint | Wrist Joint |
| Adduction | Extension | Internal Rotation | Flexion | flexion |
| Deltoid Anterior | 546 | -0.27 | -0.03 | -0.7 |  |  |
| Deltoid Lateral | 739 | -1 |  |  |  |  |
| Deltoid Posterior | 469 | -0.17 | 0.7 | -0.13 |  |  |
| Coracobrachialis | 240 | 0.23 | -0.55 | 0.22 |  |  |
| Supraspinatus | 480 | -0.59 |  | -0.41 |  |  |
| Infraspinatus | 994 |  |  | -1 |  |  |
| Teres Minor | 370 | 0.23 |  | -0.77 |  |  |
| Subscapularis | 1770 |  |  | 1 |  |  |
| Teres Major | 250 | 0.24 | 0.43 | 0.33 |  |  |
| Latissimus Dorsi | 1390 | 0.22 | 0.5 | 0.28 |  |  |
| Pectoralis Clavicular | 307 | 0.11 | -0.53 | 0.36 |  |  |
| Pectoralis Major | 1070 | 0.26 |  | 0.74 |  |  |
| Brachialis | 1440 |  |  |  | 1 |  |
| Biceps Brachii Long Head | 450 | 0.12 | -0.24 | 0.22 | 0.42 |  |
| Biceps Brachii Short Head | 175 | 0.12 | -0.24 | 0.22 | 0.42 |  |
| Brachioradialis | 390 |  |  |  | 1 |  |
| Triceps Long Head | 820 | 0.18 | 0.58 |  | 0.24 |  |
| Triceps Lateral Head | 995 |  |  |  | 1 |  |
| Triceps Medial Head | 995 |  |  |  | 1 |  |
| Anconeus | 130 |  |  |  | 1 |  |
| Pronator Teres | 650 |  |  |  | -1 |  |
| Flexor Carpi Radialis | 644 |  |  |  | 0.17 | 0.83 |
| Palmaris Longus | 681 |  |  |  | 0.11 | 0.89 |
| Flexor Carpi Ulnaris | 842 |  |  |  | 0.35 | 0.65 |
| Flexor Digit Superfic | 453 |  |  |  | 0.35 | 0.65 |
| Flexor Digi Profundus | 692 |  |  |  | 0.35 | 0.65 |
| Flexor Pollicis Longus | 417 |  |  |  | 0.35 | 0.65 |
| Extensor Carpi Ulnaris | 644 |  |  |  |  | -1 |
| Extensor Carpi Radialis Brevis | 781 |  |  |  | -0.47 | -0.53 |
| Extensor Carpi Radialis Longus | 500 |  |  |  | -0.47 | -0.53 |
| Extensor Digitorium | 198 |  |  |  | -0.47 | -0.53 |
| Extensor Indicis | 178 |  |  |  | -0.47 | -0.53 |
| Extensor Digit Minimi | 181 |  |  |  | -0.47 | -0.53 |
| Extensor Pollicis Longus | 198 |  |  |  | -0.47 | -0.53 |
| Extensor Pollicis Brevis | 143 |  |  |  | -0.47 | -0.53 |
| Abductor Pollicis Longus | 449 |  |  |  | -0.47 | -0.53 |

Table A5. Percentage Contribution and PCSA of Lower Extremity Muscles

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Muscle | PCSA  (mm2) | Hip Joint | | | Knee Joint | Ankle Joint | |
| Adduction | Flexion | Internal Rotation | Flexion | Inversion | Plantarflexion |
| Psoas Major | 2570 |  | 1 |  |  |  |  |
| Iliacus | 1130 |  | 1 |  |  |  |  |
| Sartorius | 258 | -0.1 | 0.23 | -0.15 | 0.52 |  |  |
| Rectus Femoris | 6620 |  | 0.3 |  | -0.7 |  |  |
| Tensor Fasciae Latae | 246 | -0.19 | 0.04 | 0.77 |  |  |  |
| Piriformis | 1000 | -0.38 | 0.19 | -0.43 |  |  |  |
| Superior Gemellus | 89 |  | -0.28 | -0.72 |  |  |  |
| Inferior Gemellus | 144 |  | -0.28 | -0.72 |  |  |  |
| Obturator Externus | 271 | -0.5 |  | -0.5 |  |  |  |
| Obturator Internus | 907 | -0.24 | -0.02 | -0.74 |  |  |  |
| Quadratus Femoris | 462 | -0.5 |  | -0.5 |  |  |  |
| Gluteus Minimus | 900 | -0.8 |  | 0.2 |  |  |  |
| Gluteus Medius | 2516.1 | -0.8 |  | 0.2 |  |  |  |
| Gluteus Maximus | 2300 | -0.3 | -0.28 | -0.42 |  |  |  |
| Semitendinosus | 490 | 0.24 | -0.3 | 0.25 | 0.21 |  |  |
| Semimembranosus | 2100 | 0.24 | -0.3 | 0.25 | 0.21 |  |  |
| Biceps Femoris Long Head | 1282 | 0.04 | -0.31 | -0.31 | 0.34 |  |  |
| Biceps Femoris Short Head | 814 |  |  |  | 1 |  |  |
| Adductor Brevis | 552 | 0.4 | 0.04 | 0.56 |  |  |  |
| Adductor Longus | 726 | 0.4 | 0.04 | 0.56 |  |  |  |
| Adductor Magnus | 2100 | 0.35 | 0.26 | 0.39 |  |  |  |
| Pectineus | 322 | 0.39 | 0.11 | 0.5 |  |  |  |
| Gracilis | 4595 | 0.32 | -0.05 | 0.32 | 0.31 |  |  |
| Vastus Lateralis | 6240 |  |  |  | -1 |  |  |
| Vastus Intermedius | 8350 |  |  |  | -1 |  |  |
| Vastus Medialis | 6800 |  |  |  | -1 |  |  |
| Popliteus | 551 |  |  |  | 1 |  |  |
| Gastrocnemius Medial Head | 6800 |  |  |  | 0.68 | 0.22 | 0.11 |
| Gastrocnemius Lateral Head | 2800 |  |  |  | 0.68 | 0.22 | 0.11 |
| Soleus | 5800 |  |  |  |  | 0.37 | 0.63 |
| Plantaris | 321 |  |  |  | 0.88 |  | 0.12 |
| Peroneus Longus | 2465 |  |  |  |  | -0.93 | 0.07 |
| Peroneus Brevis | 1961 |  |  |  |  | -0.93 | 0.07 |
| Extensor Digitorum Longus | 746 |  |  |  |  | -0.61 | -0.39 |
| Extensor Hallucis Longus | 649 |  |  |  |  |  | -1 |
| Tibialis Anterior | 1900 |  |  |  |  | 0.39 | -0.61 |
| Tibialis Posterior | 2627 |  |  |  |  | 0.73 | 0.27 |
| Flexor Digitorum Longus | 613 |  |  |  |  | 0.55 | 0.45 |
| Flexor Hallucis Longus | 1374 |  |  |  |  | 0.44 | 0.56 |

The negative sign indicates the muscle action is the opposite of that mentioned in the column heading.

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| --- |
|  |
| Figure A1. PID controlled muscle activation feedback control system, SF: Sigmoid function, OA: Overall activation, mat: Hill-Type muscle material model, Fm: Muscle force, θmeas: Measured angle, θref: Reference angle, θdel: Delayed measured angle |
|  |
| Figure A2. Schematic showing set angle strategy for relaxed and braced condition simulations |

Table A6. Regional Joint angles used for the PID controllers

|  |  |  |  |
| --- | --- | --- | --- |
| Angle | Direction | Right | Left |
| Neck | X | 1 | |
| Neck | Y | 1 | |
| Neck | Z | 1 | |
| Scapulo-Thoracic | X | 1 | 1 |
| Scapulo-Thoracic | Z | 1 | 1 |
| Glenohumeral | X | 1 | 1 |
| Glenohumeral | Y | 1 | 1 |
| Glenohumeral | Z | 1 | 1 |
| Elbow | Y | 1 | 1 |
| Wrist | X | 1 | 1 |
| Thorax-Pelvis | X | 1 | |
| Thorax-Pelvis | Y | 1 | |
| Thorax-Pelvis | Z | 1 | |
| Hip | X | 1 | 1 |
| Hip | Y | 1 | 1 |
| Hip | Z | 1 | 1 |
| Knee | Y | 1 | 1 |
| Ankle | X | 1 | 1 |
| Total | | 32 | |

Table A7. Controller Gains. Note the elbow controller is the only upper extremity controller to have a *kD* value.

|  |  |  |  |
| --- | --- | --- | --- |
| Region | (rad-1) | (rad-1ms-1) | (ms/rad) |
| Neck | 3 | 0 | 250 |
| Upper Ex. | 4 | 0 | 0, (Elbow-250) |
| Trunk | 8 | 0 | 0 |
| Lower Ex. | 2 | 0 | 0 |

Table A8. CORA scores for GHBMC M50-OS+Active in the relaxed condition at 2.5g acceleration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Signal | Corridor | Shape | Size | Phase | CORA score |
| Steering Column Force | 0.444 | 0.945 | 0.487 | 0.000 | 0.460 |
| Right Pedal Force | 0.594 | 0.901 | 0.867 | 1.000 | 0.758 |
| Left Pedal Force | 0.597 | 0.908 | 0.965 | 1.000 | 0.777 |
| Shoulder Belt Force | 0.572 | 0.867 | 0.614 | 0.888 | 0.680 |
| Lap Belt Force | 0.519 | 0.920 | 0.695 | 0.891 | 0.677 |
| Seatpan Force | 0.566 | 0.975 | 0.999 | 0.967 | 0.773 |
| Seatback Force | 0.432 | 0.889 | 0.633 | 0.859 | 0.612 |
| Retractor Belt Force | 0.082 | 0.832 | 0.493 | 0.879 | 0.408 |
| Head CG Linear Acceleration | 0.334 | 0.878 | 0.446 | 1.000 | 0.554 |
| Head CG Rotational Acceleration | 0.414 | 0.843 | 0.353 | 0.844 | 0.547 |
| C7 Linear Acceleration | 0.392 | 0.576 | 0.444 | 1.000 | 0.532 |
| Sternum Linear Acceleration | 0.490 | 0.718 | 0.632 | 0.459 | 0.546 |
| Sacrum Linear Acceleration | 0.525 | 0.784 | 0.433 | 1.000 | 0.632 |
|  | Total CORA rating | | | | 0.612 |

Table A9. CORA scores for GHBMC M50-OS+Active in the relaxed condition at 5g acceleration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Signal | Corridor | Shape | Size | Phase | CORA score |
| Steering Column Force | 0.647 | 0.940 | 0.511 | 0.000 | 0.565 |
| Right Pedal Force | 0.505 | 0.834 | 0.569 | 1.000 | 0.653 |
| Left Pedal Force | 0.521 | 0.857 | 0.767 | 1.000 | 0.697 |
| Shoulder Belt Force | 0.762 | 0.969 | 0.699 | 1.000 | 0.825 |
| Lap Belt Force | 0.458 | 0.989 | 1.000 | 1.000 | 0.727 |
| Seatpan Force | 0.618 | 0.937 | 0.853 | 1.000 | 0.774 |
| Seatback Force | 0.442 | 0.775 | 0.400 | 1.000 | 0.583 |
| Retractor Belt Force | 0.373 | 0.952 | 0.573 | 1.000 | 0.607 |
| Head CG Linear Acceleration | 0.582 | 0.938 | 0.897 | 1.000 | 0.763 |
| Head CG Rotational Acceleration | 0.359 | 0.824 | 0.545 | 1.000 | 0.574 |
| C7 Linear Acceleration | 0.504 | 0.733 | 0.811 | 1.000 | 0.676 |
| Sternum Linear Acceleration | 0.526 | 0.794 | 0.668 | 1.000 | 0.673 |
| Sacrum Linear Acceleration | 0.584 | 0.858 | 0.418 | 1.000 | 0.671 |
|  | Total CORA rating | | | | 0.676 |

Table A10. CORA scores for GHBMC M50-OS+Active in the braced condition at 2.5g acceleration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Signal | Corridor | Shape | Size | Phase | CORA score |
| Steering Column Force | 0.389 | 0.875 | 0.143 | 1.000 | 0.530 |
| Right Pedal Force | 0.646 | 0.976 | 0.417 | 1.000 | 0.721 |
| Left Pedal Force | 0.813 | 0.937 | 0.252 | 1.000 | 0.771 |
| Shoulder Belt Force | 0.894 | 0.960 | 0.872 | 0.900 | 0.902 |
| Lap Belt Force | 0.700 | 0.767 | 0.630 | 1.000 | 0.749 |
| Seatpan Force | 0.782 | 0.977 | 0.225 | 1.000 | 0.758 |
| Seatback Force | 0.350 | 0.967 | 0.184 | 1.000 | 0.533 |
| Retractor Belt Force | 0.153 | -0.125 | 0.000 | 1.000 | 0.222 |
| Head CG Linear Acceleration | 0.430 | 0.929 | 0.876 | 1.000 | 0.682 |
| Head CG Rotational Acceleration | 0.390 | 0.750 | 0.161 | 1.000 | 0.513 |
| C7 Linear Acceleration | 0.694 | 0.903 | 0.777 | 0.411 | 0.695 |
| Sternum Linear Acceleration | 0.715 | 0.896 | 0.796 | 1.000 | 0.806 |
| Sacrum Linear Acceleration | 0.871 | 0.957 | 0.648 | 1.000 | 0.869 |
|  | Total CORA rating | | | | 0.673 |

Table A11. CORA scores for GHBMC M50-OS+Active in the braced condition at 5g acceleration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Signal | Corridor | Shape | Size | Phase | CORA score |
| Steering Column Force | 0.431 | 0.879 | 0.244 | 1.000 | 0.569 |
| Right Pedal Force | 0.597 | 0.897 | 0.540 | 1.000 | 0.704 |
| Left Pedal Force | 0.766 | 0.870 | 0.560 | 1.000 | 0.788 |
| Shoulder Belt Force | 0.808 | 0.970 | 0.394 | 1.000 | 0.798 |
| Lap Belt Force | 0.721 | 0.975 | 0.312 | 1.000 | 0.741 |
| Seatpan Force | 0.808 | 0.949 | 0.500 | 1.000 | 0.812 |
| Seatback Force | 0.521 | 0.883 | 0.274 | 1.000 | 0.620 |
| Retractor Belt Force | 0.302 | 0.910 | 0.548 | 1.000 | 0.560 |
| Head CG Linear Acceleration | 0.515 | 0.953 | 0.710 | 1.000 | 0.701 |
| Head CG Rotational Acceleration | 0.535 | 0.841 | 0.480 | 1.000 | 0.654 |
| C7 Linear Acceleration | 0.690 | 0.911 | 0.573 | 0.976 | 0.755 |
| Sternum Linear Acceleration | 0.657 | 0.915 | 0.684 | 1.000 | 0.761 |
| Sacrum Linear Acceleration | 0.761 | 0.895 | 0.634 | 1.000 | 0.802 |
|  | Total CORA rating | | | | 0.713 |

Table A12. CORA scores for GHBMC M50-OS in the relaxed condition at 2.5g acceleration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Signal | Corridor | Shape | Size | Phase | CORA score |
| Steering Column Force | 0.528 | 0.975 | 0.284 | 0.000 | 0.474 |
| Right Pedal Force | 0.532 | 0.837 | 0.822 | 1.000 | 0.709 |
| Left Pedal Force | 0.622 | 0.865 | 0.620 | 1.000 | 0.725 |
| Shoulder Belt Force | 0.567 | 0.887 | 0.918 | 0.829 | 0.722 |
| Lap Belt Force | 0.484 | 0.943 | 0.919 | 0.820 | 0.689 |
| Seatpan Force | 0.671 | 0.986 | 0.889 | 1.000 | 0.814 |
| Seatback Force | 0.357 | 0.897 | 0.299 | 0.826 | 0.515 |
| Retractor Belt Force | 0.072 | 0.850 | 0.839 | 0.832 | 0.456 |
| Head CG Linear Acceleration | 0.713 | 0.926 | 0.976 | 1.000 | 0.840 |
| Head CG Rotational Acceleration | 0.433 | 0.920 | 0.358 | 0.888 | 0.577 |
| C7 Linear Acceleration | 0.319 | 0.770 | 0.728 | 0.603 | 0.509 |
| Sternum Linear Acceleration | 0.383 | 0.747 | 0.455 | 1.000 | 0.558 |
| Sacrum Linear Acceleration | 0.535 | 0.908 | 0.368 | 1.000 | 0.646 |
|  | Total CORA rating | | | | 0.633 |

Table A13. CORA scores for GHBMC M50-OS in the relaxed condition at 5g acceleration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Signal | Corridor | Shape | Size | Phase | CORA score |
| Steering Column Force | 0.620 | 0.933 | 0.289 | 0.000 | 0.513 |
| Right Pedal Force | 0.434 | 0.765 | 0.754 | 1.000 | 0.636 |
| Left Pedal Force | 0.469 | 0.912 | 0.648 | 1.000 | 0.661 |
| Shoulder Belt Force | 0.736 | 0.971 | 0.951 | 1.000 | 0.855 |
| Lap Belt Force | 0.378 | 0.991 | 0.958 | 1.000 | 0.680 |
| Seatpan Force | 0.540 | 0.951 | 0.925 | 1.000 | 0.749 |
| Seatback Force | 0.221 | 0.895 | 0.132 | 1.000 | 0.448 |
| Retractor Belt Force | 0.390 | 0.963 | 0.742 | 1.000 | 0.645 |
| Head CG Linear Acceleration | 0.564 | 0.926 | 0.884 | 1.000 | 0.750 |
| Head CG Rotational Acceleration | 0.466 | 0.847 | 0.541 | 0.926 | 0.618 |
| C7 Linear Acceleration | 0.459 | 0.803 | 0.660 | 1.000 | 0.640 |
| Sternum Linear Acceleration | 0.382 | 0.792 | 0.607 | 1.000 | 0.590 |
| Sacrum Linear Acceleration | 0.642 | 0.926 | 0.423 | 1.000 | 0.712 |
|  | Total CORA rating | | | | 0.654 |

Table A14. CORA scores for GHBMC M50-OS in the braced condition at 2.5g acceleration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Signal | Corridor | Shape | Size | Phase | CORA score |
| Steering Column Force | 0.125 | 0.913 | 0.045 | 0.915 | 0.374 |
| Right Pedal Force | 0.086 | 0.673 | 0.083 | 1.000 | 0.335 |
| Left Pedal Force | 0.350 | 0.789 | 0.075 | 1.000 | 0.485 |
| Shoulder Belt Force | 0.682 | 0.805 | 0.028 | 1.000 | 0.646 |
| Lap Belt Force | 0.611 | 0.682 | 0.176 | 1.000 | 0.615 |
| Seatpan Force | 0.267 | 0.947 | 0.073 | 0.000 | 0.303 |
| Seatback Force | 0.110 | 0.658 | 0.023 | 0.594 | 0.267 |
| Retractor Belt Force | 0.107 | 0.699 | 0.038 | 1.000 | 0.343 |
| Head CG Linear Acceleration | 0.478 | 0.958 | 0.877 | 0.676 | 0.657 |
| Head CG Rotational Acceleration | 0.310 | 0.954 | 0.228 | 0.438 | 0.425 |
| C7 Linear Acceleration | 0.452 | 0.804 | 0.900 | 1.000 | 0.676 |
| Sternum Linear Acceleration | 0.410 | 0.795 | 0.723 | 1.000 | 0.624 |
| Sacrum Linear Acceleration | 0.821 | 0.850 | 0.767 | 1.000 | 0.846 |
|  | Total CORA rating | | | | 0.508 |

Table A15. CORA scores for GHBMC M50-OS in the braced condition at 5g acceleration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Signal | Corridor | Shape | Size | Phase | CORA score |
| Steering Column Force | 0.160 | 0.904 | 0.091 | 1.000 | 0.412 |
| Right Pedal Force | 0.124 | 0.585 | 0.152 | 1.000 | 0.351 |
| Left Pedal Force | 0.379 | 0.741 | 0.161 | 1.000 | 0.506 |
| Shoulder Belt Force | 0.617 | 0.983 | 0.053 | 1.000 | 0.647 |
| Lap Belt Force | 0.599 | 0.975 | 0.133 | 1.000 | 0.650 |
| Seatpan Force | 0.398 | 0.892 | 0.189 | 0.000 | 0.379 |
| Seatback Force | 0.283 | 0.698 | 0.036 | 1.000 | 0.430 |
| Retractor Belt Force | 0.291 | 0.970 | 0.063 | 1.000 | 0.484 |
| Head CG Linear Acceleration | 0.604 | 0.932 | 0.989 | 1.000 | 0.788 |
| Head CG Rotational Acceleration | 0.432 | 0.842 | 0.218 | 0.120 | 0.412 |
| C7 Linear Acceleration | 0.546 | 0.794 | 0.916 | 1.000 | 0.724 |
| Sternum Linear Acceleration | 0.554 | 0.768 | 0.942 | 1.000 | 0.728 |
| Sacrum Linear Acceleration | 0.815 | 0.884 | 0.507 | 1.000 | 0.806 |
|  | Total CORA rating | | | | 0.563 |

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| Figure A3. Comparison of simulation response for M50-OS (Control: shown as transparent colored skin) and M50-OS+Active at the time of highest head CG forward excursion in 5g relaxed condition |

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| Figure A4. Head CG displacement response of M50-OS and M50-OS+Active along with experimental data (Beeman, et al. 2011) | |

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| Figure A5. Head CG displacement response of M50-OS along with experimental PMHS data (Beeman, et al. 2012) | |

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| Figure A6. Comparison of steering column force, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A7. Comparison of right pedal force, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A8. Comparison of left pedal force, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A9. Comparison of seatpan force, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A10. Comparison of seatback force, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A11. Comparison of shoulder belt force, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A12. Comparison of lap belt force, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A13. Comparison of retractor belt force, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A14. Comparison of head CG linear acceleration, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A15. Comparison of head CG angular acceleration, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A16. Comparison of C7 linear acceleration, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A17. Comparison of sternum linear acceleration, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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| Figure A18. Comparison of sacrum linear acceleration, by muscle state and pulse severity, for M50-OS+Active, M50-OS, and volunteer data (Kemper, et al. 2014) | |

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