Appendix

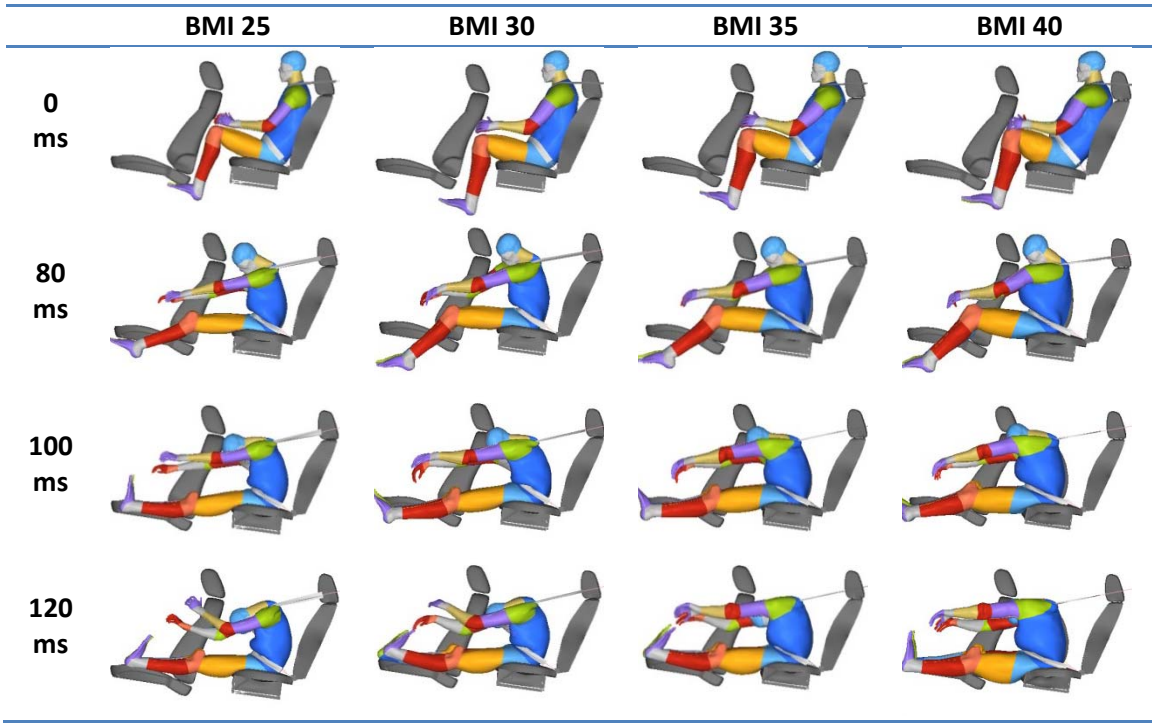

Figure A1. Kinematics of different BMI occupants with a standard 3-point belt

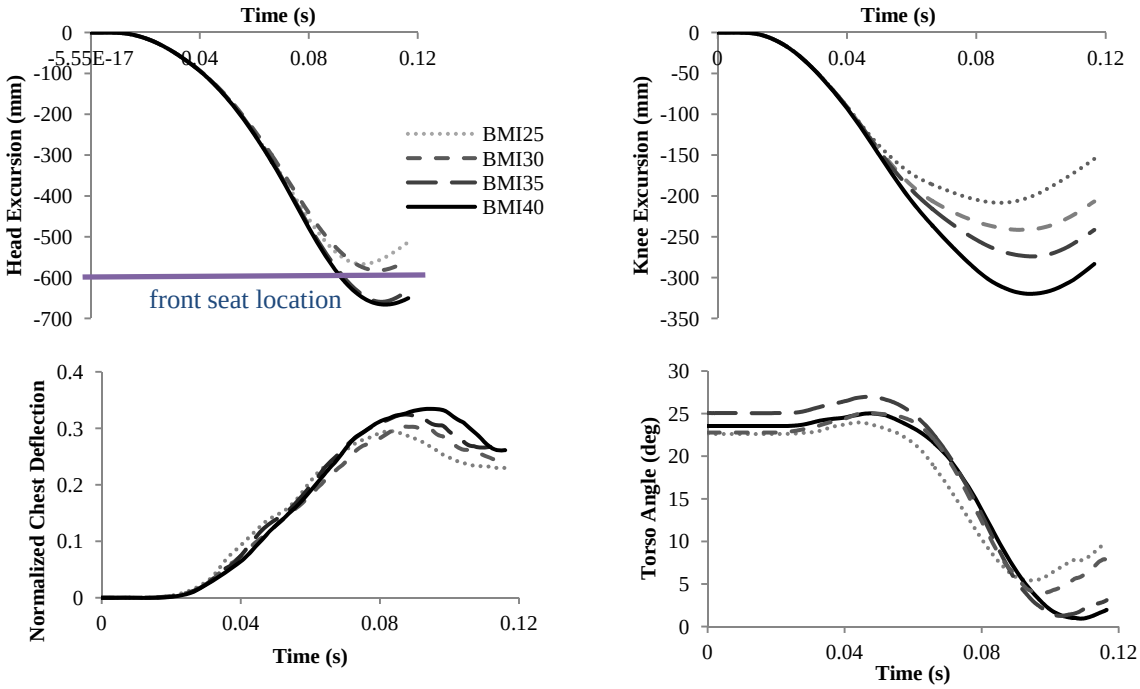

Figure A2. BMI effects on occupant responses with a standard 3-point belt

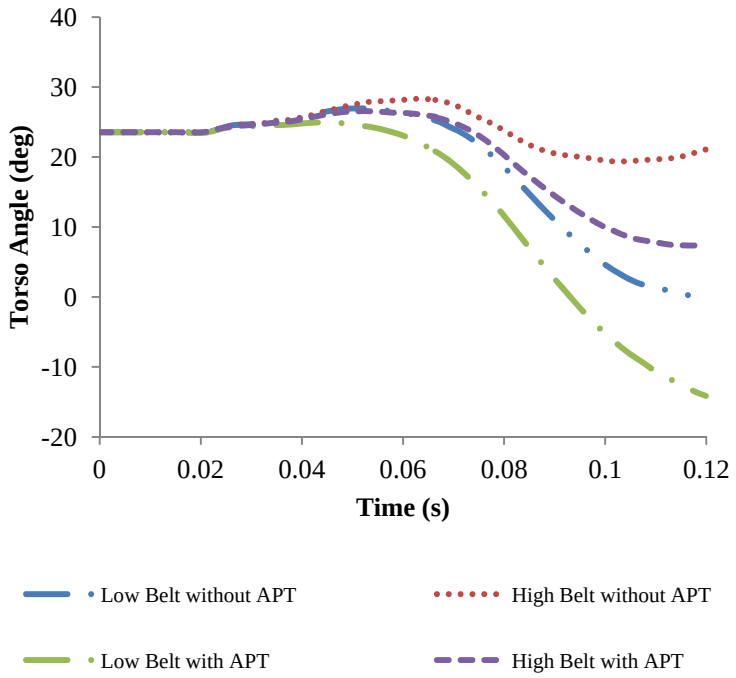

Figure A3. Torso angles for the BMI 40 occupant under different belt conditions

Table A1. Parameter combinations simulated in the parametric study

Test NO.	BMI (Kg/m^2)	Belt Position	Load Limiter Force (KN)	Pretensioner	**Test NO.**	BMI (Kg/m^2)	Belt Position	Load Limiter Force (KN)	Pretensioner
1	25	Low	4	Yes	**25**	35	High	4	No
2	25	Low	5.6	Yes	**26**	35	High	5.6	No
3	25	High	4	No	**27**	35	High	6.8	Yes
4	25	High	6.8	No	**28**	35	High	6.8	No
5	25	High	6.8	Yes	**29**	35	Low	5.6	No
6	25	High	5.6	Yes	**30**	35	Low	5.6	Yes
7	25	Low	6.8	Yes	**31**	35	High	4	Yes
8	25	High	4	Yes	**32**	35	High	5.6	Yes
9	25	Low	4	No	**33**	35	Low	4	Yes
10	25	Low	5.6	No	**34**	35	Low	6.8	Yes
11	25	Low	6.8	No	**35**	35	Low	4	No
12	25	High	5.6	No	**36**	35	Low	6.8	No
13	30	Low	4	No	**37**	40	Low	6.8	No
14	30	Low	6.8	No	**38**	40	Low	5.6	No
15	30	Low	6.8	Yes	**39**	40	Low	4	No
16	30	Low	5.6	Yes	**40**	40	Low	5.6	Yes
17	30	High	6.8	Yes	**41**	40	High	4	No
18	30	High	4	Yes	**42**	40	High	4	Yes
19	30	Low	5.6	No	**43**	40	High	5.6	No
20	30	High	4	No	**44**	40	High	6.8	No
21	30	High	6.8	No	**45**	40	Low	4	Yes
22	30	Low	4	Yes	**46**	40	Low	6.8	Yes
23	30	High	5.6	Yes	**47**	40	High	5.6	Yes
24	30	High	5.6	No	**48**	40	High	6.8	Yes

Table A2. Maximum value of the kinematics and chest deflection for different tests

Test NO.	Head Excursion (mm)	Shoulder excursion (mm)	Knee excursion (mm)	Pelvis excursion (mm)	Shoulder belt Force (N)	Normalized chest deflection	Torso Angle (deg)
1	622	292	169	121	5588	0.247	-7.7
2	520	209	168	120	7329	0.269	11.6
3	612	285	230	182	6028	0.250	6.8
4	483	203	228	184	8304	0.295	22.6
5	488	196	183	136	8068	0.283	17.6
6	503	198	183	136	7309	0.282	16.8
7	493	203	163	117	8142	0.273	12.8
8	599	269	182	134	5924	0.250	0.8
9	622	285	210	161	6004	0.239	1.8
10	520	209	206	158	7240	0.270	18.8
11	499	206	205	157	8250	0.280	19.6
12	511	214	229	181	7320	0.280	22.6
13	673	395	244	211	5547	0.252	-13.6
14	563	323	255	236	8563	0.298	8.2
15	554	306	190	154	8689	0.295	-5.0
16	585	332	190	155	7442	0.285	-12.6
17	548	302	209	174	8603	0.305	0.8
18	676	425	213	176	5510	0.254	-27.4
19	594	343	253	227	7433	0.276	2.0
20	695	430	265	237	5575	0.251	-14.4
21	558	312	263	237	8520	0.300	11.0
22	691	419	194	158	5568	0.243	-30.3
23	581	326	210	174	7436	0.285	-6.4
24	626	371	264	237	7047	0.275	-1.7
25	754	498	320	286	5743	0.260	-5.4
26	668	405	309	275	7617	0.281	8.5
27	621	362	245	203	8856	0.305	2.2
28	639	378	301	266	8801	0.296	11.4
29	672	414	257	211	7618	0.289	-6.7
30	682	429	209	165	7529	0.277	-18.4
31	752	493	248	208	5772	0.259	-19.9
32	655	387	246	204	7495	0.286	-3.0
33	774	524	211	166	5700	0.255	-31.2
34	648	386	209	164	8852	0.300	-10.5
35	760	513	260	214	5723	0.261	-22.6
36	638	386	256	210	8765	0.306	-1.2
37	688	449	324	275	9013	0.313	-0.1
38	724	486	325	274	7689	0.296	-5.9
39	802	579	327	275	6560	0.273	-20.3
40	726	489	256	204	7741	0.292	-20.1
41	803	571	441	423	6540	0.253	4.8
42	789	552	329	289	6474	0.264	-13.0
43	719	475	432	413	7829	0.278	16.2
44	674	444	431	411	8980	0.297	19.4
45	813	586	258	206	6121	0.259	-33.1
46	689	447	257	204	8942	0.310	-14.1
47	699	455	325	285	7688	0.305	0.3
48	660	418	332	290	8935	0.302	7.4

Table A3. Occupant response comparison between baseline belt and advanced belt systems

BMI	Belt type	Load Limiter Force (kN)	Head Excursion (mm)	Knee Excursion (mm)	Shoulder belt Force (N)	Normalized chest deflection	Torso Angle (deg)
25	Baseline	--	567	208	8,946	0.295	5.4
	Advanced	5.6kN	520	168	7,329	0.268	11.6
30	Baseline	--	583	241	10,737	0.303	-1.1
	Advanced	5.6kN	585	190	7,442	0.285	-12.6
35	Baseline	--	659	274	12,088	0.325	1.3
	Advanced	6.8kN	648	209	8,852	0.300	-10.5
40	Baseline	--	666	320	13,621	0.335	0.9
	Advanced	6.8kN	689	257	8,942	0.310	-14.2