Table 4. Simulation Scenarios from Experimental Observations (sample listing)

scenario	speed in/sec	operator height, in	response time, msec	risk behavior {B1, B2}		postures knee	collision totals		
							raw	avoid	hit
111111	7	63	250	0	0	2	7	5	2
111112	7	63	250	0	0	1	12	6	6
111121	7	63	250	0	1	2	10	5	5
111122	7	63	250	0	1	1	13	7	6
111211	7	63	250	1	0	2	2	1	1
111212	7	63	250	1	0	1	0	0	0
111221	7	63	250	1	1	2	0	0	0
111222	7	63	250	1	1	1	1	1	0
112111	7	63	400	0	0	2	7	5	2
112112	7	63	400	0	0	1	12	6	6
112121	7	63	400	0	1	2	10	5	5
112122	7	63	400	0	1	1	13	7	6
112211	7	63	400	1	0	2	2	1	1
112212	7	63	400	1	0	1	0	0	0
112221	7	63	400	1	1	2	0	0	0
112222	7	63	400	1	1	1	1	1	0
121111	7	69	250	0	0	2	0	0	0
121112	7	69	250	0	0	1	1	0	1

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scenario	speed in/sec	operator height, in	response time, msec	risk behavior {B1, B2}		postures knee	collision totals		
432122	22	75	400	0	1	1	8	0	8
432211	22	75	400	1	0	2	0	0	0
432212	22	75	400	1	0	1	0	0	0
432221	22	75	400	1	1	2	0	0	0
432222	22	75	400	1	1	1	1	0	1

Collisions versus speed, operator's size, and risk behaviors demonstrate the versatility found in the data obtained from the model. Response time significantly affects the number of collisions experienced by the virtual subject (figures 4a, 4b). Also, simulation data indicates that lower seam heights have more mishaps and are more sensitive to the two response times in this experiment. Factors such as age, strength or other constraints relating to a person's reaction time could be used to generate a tailored response time. Experimental data (figures 5a, 5b thru 8a, 8b) indicates that more mishaps occur with risk behavior {0,1}, hands on the boom arm. The lower seam height significantly affect mishaps only in one risk behavior {0,1}, hands on the boom arm.

CONCLUSION

Ergonomists who provided technical support for this work were overwhelmed with the infinite possibilities of test scenarios, because there were no limitations placed on the virtual human operator. Simulations also provided an interesting approach to data gathering in that logistics—mine sites and costs associated with experiments—became insignificant. The model requires further enhancements to streamline its efficiency. For example, the model's code undergoes numerous but minor changes to accommodate all test series and setups of each simulation test run. Automating the modification procedure that changes the code would improve the model's ease of use. Also, at present there is no automatic scheme in the model to detect when the boom arm enters and leaves an operator's viewing area. Response times rely on this information. Thus the time element used to ascertain what collisions could have