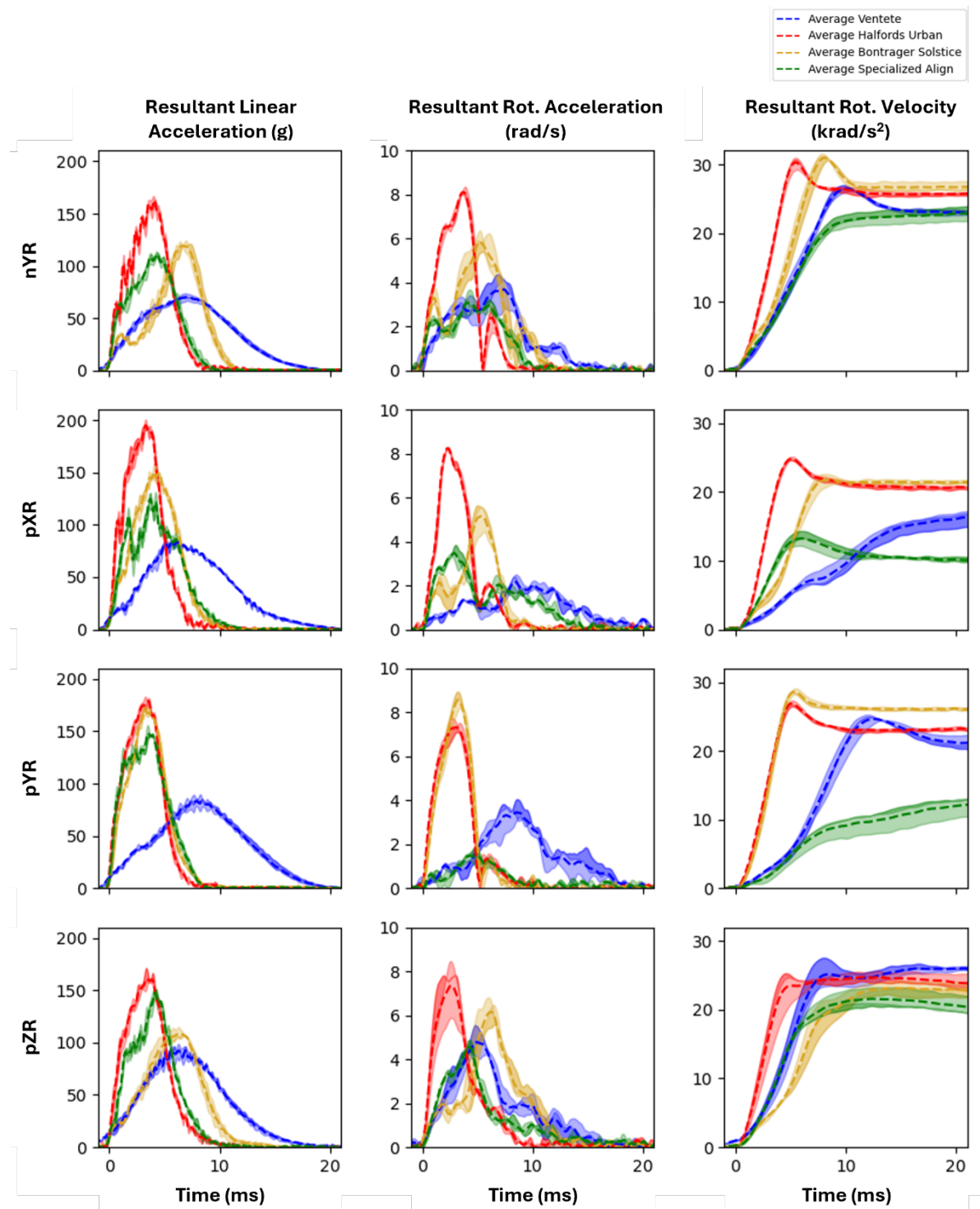


## Appendix 1

Time-history of all kinematic measurements for all tested helmet models across all impact locations. The dotted line represents the average resultant kinematics. The colour-filled area represents the range between the maximum and minimum values across the three repetitions of each helmet.



## Appendix 2

Kinematic results for all repeats of helmets, in addition to mean, standard deviation, coefficients of variation for the peak linear acceleration (PLA), peak rotational velocity (PRV), peak rotational acceleration (PRA) and the brain injury criterion (BrIC). Non-weighted linear and rotational risk for each impact are also included.

| Test ID                        | Impact | PLA (g) | PRV (rad/s) | PRA (krad/s <sup>2</sup> ) | BrIC  | Non-weighted Linear Risk | Non-weighted Rot Risk |
|--------------------------------|--------|---------|-------------|----------------------------|-------|--------------------------|-----------------------|
| 2024-03-25_Ventete_pXR_01      | pXR    | 85.3    | 17.8        | 2.5                        | 0.324 | 0.100                    | 0.158                 |
| 2024-03-25_Ventete_pXR_02      |        | 85.1    | 15.6        | 2.4                        | 0.293 | 0.099                    | 0.121                 |
| 2024-03-25_Ventete_pXR_03      |        | 84.8    | 18.0        | 1.9                        | 0.342 | 0.099                    | 0.182                 |
| Average                        |        | 85.1    | 17.1        | 2.3                        | 0.320 | 0.099                    | 0.154                 |
| SD                             |        | 0.3     | 1.3         | 0.3                        | 0.025 | 0.000                    | 0.031                 |
| Coefficient of Variance (%)    |        | 3%      | 8%          | 14%                        | 8%    | 0%                       | 20%                   |
| 2024-03-25_Ventete_pYR_04      | pYR    | 78.9    | 24.5        | 3.2                        | 0.446 | 0.092                    | 0.346                 |
| 2024-03-25_Ventete_pYR_05      |        | 85.9    | 25.0        | 4.1                        | 0.479 | 0.100                    | 0.408                 |
| 2024-03-25_Ventete_pYR_06      |        | 89.8    | 25.3        | 3.7                        | 0.465 | 0.105                    | 0.382                 |
| Average                        |        | 84.9    | 24.9        | 3.7                        | 0.463 | 0.099                    | 0.379                 |
| SD                             |        | 5.5     | 0.4         | 0.4                        | 0.017 | 0.006                    | 0.031                 |
| Coefficient of Variance        |        | 7%      | 2%          | 11%                        | 4%    | 6%                       | 8%                    |
| 2024-03-25_Ventete_nYR_04      | nYR    | 66.8    | 26.1        | 3.4                        | 0.468 | 0.080                    | 0.387                 |
| 2024-03-25_Ventete_nYR_05      |        | 70.0    | 27.0        | 4.4                        | 0.487 | 0.083                    | 0.421                 |
| 2024-03-25_Ventete_nYR_06      |        | 73.9    | 26.5        | 4.2                        | 0.477 | 0.087                    | 0.404                 |
| Average                        |        | 70.2    | 26.5        | 4.0                        | 0.477 | 0.083                    | 0.404                 |
| SD                             |        | 3.5     | 0.5         | 0.5                        | 0.009 | 0.004                    | 0.017                 |
| Coefficient of Variance        |        | 5%      | 2%          | 13%                        | 2%    | 4%                       | 4%                    |
| 2024-03-25_Ventete_pZR_01      | pZR    | 85.7    | 26.4        | 4.9                        | 0.667 | 0.100                    | 0.737                 |
| 2024-03-25_Ventete_pZR_02      |        | 96.5    | 27.6        | 5.6                        | 0.642 | 0.114                    | 0.699                 |
| 2024-03-25_Ventete_pZR_03      |        | 98.9    | 25.8        | 4.3                        | 0.636 | 0.117                    | 0.690                 |
| Average                        |        | 93.7    | 26.6        | 4.9                        | 0.648 | 0.110                    | 0.709                 |
| SD                             |        | 7.0     | 0.9         | 0.6                        | 0.016 | 0.009                    | 0.025                 |
| Coefficient of Variance        |        | 8%      | 3%          | 12%                        | 2%    | 8%                       | 4%                    |
| 2024-07-17_BontragerSol_pXR_01 | pXR    | 159.4   | 21.4        | 4.4                        | 0.330 | 0.226                    | 0.166                 |
| 2024-07-17_BontragerSol_pXR_02 |        | 148.3   | 21.9        | 5.6                        | 0.333 | 0.202                    | 0.169                 |
| 2024-07-17_BontragerSol_pXR_03 |        | 150.4   | 22.6        | 5.6                        | 0.349 | 0.206                    | 0.192                 |
| Average                        |        | 152.7   | 22.0        | 5.2                        | 0.337 | 0.212                    | 0.176                 |
| SD                             |        | 5.9     | 0.6         | 0.7                        | 0.010 | 0.013                    | 0.014                 |
| Coefficient of Variance        |        | 4%      | 3%          | 13%                        | 3%    | 6%                       | 8%                    |
| 2024-07-17_BontragerSol_pYR_01 | pYR    | 167.9   | 29.1        | 8.6                        | 0.518 | 0.246                    | 0.479                 |
| 2024-07-17_BontragerSol_pYR_02 |        | 174.5   | 28.6        | 9.0                        | 0.505 | 0.263                    | 0.455                 |
| 2024-07-17_BontragerSol_pYR_03 |        | 170.8   | 28.2        | 8.2                        | 0.500 | 0.254                    | 0.446                 |
| Average                        |        | 171.0   | 28.6        | 8.6                        | 0.508 | 0.254                    | 0.460                 |

|                                        |            |       |      |      |       |       |       |
|----------------------------------------|------------|-------|------|------|-------|-------|-------|
| <b>SD</b>                              | <b>nYR</b> | 3.3   | 0.4  | 0.4  | 0.009 | 0.008 | 0.017 |
| <b>Coefficient of Variance</b>         |            | 2%    | 2%   | 4%   | 2%    | 3%    | 4%    |
| <b>2024-07-17_BontragerSol_nYR_04</b>  |            | 124.3 | 31.6 | 6.2  | 0.559 | 0.156 | 0.556 |
| <b>2024-07-17_BontragerSol_nYR_05</b>  |            | 121.1 | 30.6 | 5.4  | 0.544 | 0.150 | 0.528 |
| <b>2024-07-17_BontragerSol_nYR_06</b>  |            | 120.2 | 31.2 | 6.4  | 0.556 | 0.149 | 0.551 |
| <b>Average</b>                         |            | 121.9 | 31.1 | 6.0  | 0.553 | 0.152 | 0.545 |
| <b>SD</b>                              | <b>pZR</b> | 2.1   | 0.5  | 0.5  | 0.008 | 0.004 | 0.015 |
| <b>Coefficient of Variance</b>         |            | 2%    | 2%   | 9%   | 1%    | 2%    | 3%    |
| <b>2024-07-30_BontragerSol_pZR_04</b>  |            | 106.5 | 23.3 | 6.5  | 0.572 | 0.128 | 0.579 |
| <b>2024-07-30_BontragerSol_pZR_05</b>  |            | 108.3 | 22.3 | 5.6  | 0.536 | 0.130 | 0.513 |
| <b>2024-07-30_BontragerSol_pZR_06</b>  |            | 114.8 | 24.2 | 6.8  | 0.586 | 0.140 | 0.604 |
| <b>Average</b>                         |            | 109.9 | 23.3 | 6.3  | 0.565 | 0.133 | 0.565 |
| <b>SD</b>                              | <b>pXR</b> | 4.4   | 1.0  | 0.6  | 0.026 | 0.007 | 0.047 |
| <b>Coefficient of Variance</b>         |            | 4%    | 4%   | 10%  | 5%    | 5%    | 8%    |
| <b>2024_07_17_SpecializedA_pXR_01</b>  |            | 120.3 | 12.2 | 3.5  | 0.252 | 0.149 | 0.081 |
| <b>2024_07_17_SpecializedA_pXR_02</b>  |            | 130.4 | 14.3 | 3.8  | 0.292 | 0.167 | 0.120 |
| <b>2024_07_17_SpecializedA_pXR_03</b>  |            | 131.4 | 13.3 | 3.4  | 0.278 | 0.168 | 0.106 |
| <b>Average</b>                         |            | 127.3 | 13.3 | 3.6  | 0.274 | 0.161 | 0.102 |
| <b>SD</b>                              | <b>pYR</b> | 6.1   | 1.1  | 0.2  | 0.020 | 0.011 | 0.020 |
| <b>Coefficient of Variance</b>         |            | 5%    | 8%   | 7%   | 7%    | 7%    | 19%   |
| <b>2024_07_17_SpecializedA_pYR_01</b>  |            | 146.4 | 13.5 | 1.7  | 0.237 | 0.198 | 0.068 |
| <b>2024_07_17_SpecializedA_pYR_02</b>  |            | 148.2 | 13.3 | 1.8  | 0.236 | 0.202 | 0.067 |
| <b>2024_07_17_SpecializedA_pYR_03</b>  |            | 156.1 | 10.9 | 1.2  | 0.193 | 0.219 | 0.039 |
| <b>Average</b>                         |            | 150.2 | 12.6 | 1.6  | 0.222 | 0.206 | 0.058 |
| <b>SD</b>                              | <b>nYR</b> | 5.1   | 1.4  | 0.3  | 0.025 | 0.011 | 0.017 |
| <b>Coefficient of Variance</b>         |            | 3%    | 11%  | 19%  | 11%   | 5%    | 29%   |
| <b>2024_07_17_SpecializedA_nYR_04</b>  |            | 113.9 | 22.4 | 3.7  | 0.398 | 0.139 | 0.265 |
| <b>2024_07_17_SpecializedA_nYR_05</b>  |            | 112.7 | 24.5 | 3.2  | 0.434 | 0.137 | 0.326 |
| <b>2024_07_17_SpecializedA_nYR_06</b>  |            | 107.7 | 23.6 | 2.8  | 0.417 | 0.129 | 0.298 |
| <b>Average</b>                         |            | 111.4 | 23.5 | 3.2  | 0.416 | 0.135 | 0.296 |
| <b>SD</b>                              | <b>pZR</b> | 3.3   | 1.0  | 0.4  | 0.018 | 0.005 | 0.031 |
| <b>Coefficient of Variance</b>         |            | 3%    | 4%   | 14%  | 4%    | 4%    | 10%   |
| <b>2024_07_17_SpecializedA_pZR_04</b>  |            | 143.5 | 23.3 | 4.5  | 0.465 | 0.192 | 0.381 |
| <b>2024_07_17_SpecializedA_pZR_05</b>  |            | 151.3 | 20.6 | 4.9  | 0.424 | 0.208 | 0.309 |
| <b>2024_07_17_SpecializedA_pZR_06</b>  |            | 150.6 | 21.0 | 4.2  | 0.433 | 0.207 | 0.324 |
| <b>Average</b>                         |            | 148.5 | 21.6 | 4.6  | 0.440 | 0.202 | 0.338 |
| <b>SD</b>                              | <b>pXR</b> | 4.3   | 1.5  | 0.3  | 0.022 | 0.009 | 0.038 |
| <b>Coefficient of Variance</b>         |            | 3%    | 7%   | 7%   | 5%    | 4%    | 11%   |
| <b>2023-02-13_HalfordsUrban_pXR_01</b> |            | 194.3 | 24.8 | 8.3  | 0.390 | 0.316 | 0.253 |
| <b>2023-02-13_HalfordsUrban_pXR_02</b> |            | 193.1 | 24.6 | 8.26 | 0.378 | 0.313 | 0.234 |
| <b>2023-02-13_HalfordsUrban_pXR_03</b> |            | 200.8 | 25.2 | 8.17 | 0.395 | 0.335 | 0.261 |
| <b>Average</b>                         |            | 196.1 | 24.7 | 8.24 | 0.388 | 0.321 | 0.250 |

|                                        |            |       |       |       |       |       |       |
|----------------------------------------|------------|-------|-------|-------|-------|-------|-------|
| <b>SD</b>                              | <i>pYR</i> | 4.14  | 0.31  | 0.067 | 0.009 | 0.012 | 0.014 |
| <b>Coefficient of Variance</b>         |            | 2%    | 1%    | 1%    | 2%    | 4%    | 6%    |
| <b>2023-02-13_HalfordsUrban_pYR_01</b> |            | 183.2 | 26.9  | 7.75  | 0.475 | 0.286 | 0.400 |
| <b>2023-02-13_HalfordsUrban_pYR_02</b> |            | 180.2 | 26.5  | 7.11  | 0.469 | 0.278 | 0.389 |
| <b>2023-02-13_HalfordsUrban_pYR_03</b> |            | 175.1 | 27.3  | 7.53  | 0.484 | 0.264 | 0.416 |
| <b>Average</b>                         |            | 179.5 | 26.9  | 7.46  | 0.476 | 0.276 | 0.402 |
| <b>SD</b>                              |            | 4.1   | 0.4   | 0.33  | 0.008 | 0.011 | 0.014 |
| <b>Coefficient of Variance</b>         |            | 2%    | 1%    | 4%    | 2%    | 4%    | 3%    |
| <b>2024-02-27_HalfordsUrban_nYR_04</b> | <i>nYR</i> | 166.9 | 29.2  | 8.02  | 0.518 | 0.244 | 0.478 |
| <b>2024-02-27_HalfordsUrban_nYR_05</b> |            | 163.5 | 30.7  | 8.09  | 0.543 | 0.236 | 0.526 |
| <b>2024-02-27_HalfordsUrban_nYR_06</b> |            | 158.4 | 30.99 | 8.37  | 0.549 | 0.224 | 0.537 |
| <b>Average</b>                         |            | 162.9 | 30.3  | 8.16  | 0.536 | 0.235 | 0.514 |
| <b>SD</b>                              |            | 4.28  | 0.96  | 0.19  | 0.017 | 0.010 | 0.031 |
| <b>Coefficient of Variance</b>         |            | 3%    | 3%    | 2%    | 3%    | 4%    | 6%    |
| <b>2024-02-28_HalfordsUrban_pZR_04</b> | <i>pZR</i> | 158.2 | 25.7  | 5.88  | 0.584 | 0.224 | 0.601 |
| <b>2024-02-28_HalfordsUrban_pZR_05</b> |            | 171.2 | 25.3  | 7.83  | 0.588 | 0.255 | 0.608 |
| <b>2023-02-28_HalfordsUrban_pZR_06</b> |            | 161.6 | 24.7  | 8.47  | 0.596 | 0.231 | 0.622 |
| <b>Average</b>                         |            | 163.7 | 25.2  | 7.39  | 0.590 | 0.237 | 0.610 |
| <b>SD</b>                              |            | 6.74  | 0.5   | 1.35  | 0.006 | 0.016 | 0.011 |
| <b>Coefficient of Variance</b>         |            | 4%    | 2%    | 18%   | 1%    | 7%    | 2%    |