Statistical Analysis and Results

# 1. Statistical Analysis

The present analysis was not pre-registered as we had no a priori hypotheses and, given the limited sample size due to resource constraints and the population, thus was considered exploratory. Inferential statistics were treated as highly unstable local descriptions of the relations between model assumptions and data in order to acknowledge the inherent uncertainty in drawing generalised inferences from single and small samples (Amrhein, Trafimow, et al., 2019). For all analyses we opted to avoid dichotomising the existence of effects and therefore did not employ traditional null hypothesis significance testing on parameter estimates (Amrhein, Greenland, et al., 2019; McShane et al., 2019). Instead, we opted to take an estimation-based approach instead (Cumming, 2014), based within a Bayesian framework (Kruschke & Liddell, 2018). For all analyses model parameter estimates and their precision, along with conclusions based upon them, were interpreted continuously and probabilistically, considering data quality, plausibility of effect, and previous literature, all within the context of each model. We focused primarily on qualitative examination of our results based on visualization of the data and models for fixed effects, and exploration of variances using random effects. All analysis was performed in R (version 4.2.3, The R Foundation for Statistical Computing, 2023) and all data and code is presented in the supplementary materials (https://osf.io/y2jdb/). Two sets of models were employed exploring the sprint trial outcomes, and the repeated sprint outcomes, for both classification (4 vs 5) and disability (other vs SCI). The brms package (Bürkner, 2017) was used to fit all models. All parameters in the models described below had values , trace plots demonstrated chain convergence, and the posterior predictive checks appeared appropriate (see https://osf.io/juex5). Given population and outcomes explored, the limited data available in past studies, and the model structures, we did not have a clear intuition or informed opinion about what priors to set and so opted to use the default weakly regularising priors and “let the data speak”. Four Monte Carlo Markov Chains with 4000 warmup and 4000 sampling iterations were used in each model. For each model results were visualised by taking draws from the expected posterior distribution (n=16000) and taking the mean of these draws along with the 95% quantile (credible) interval for the fixed effects parameters, thus providing the overall grand mean effects for the population. All data visualisations were made using ggplot2 (Wickham et al., 2022), the tidybayes package (Kay & Mastny, 2022), and the patchwork package (Pedersen, 2022).

## 1.1 Sprint trial outcomes

For the sprint trials we examined both the velocities and accelerations over each of the 5m sections of the 20m sprint as dependent variables in separate models. Data was handled in long format with each row corresponding to an observation of a participants velocity or acceleration in a 5m section for a given trial. For each of velocity and acceleration we fit separate models with fixed effects for either disability or classification, and in each also included a fixed effect for the distance (i.e., section of the 20m sprint trial: 0-5m, 5-10m, 10-15m, 15-20m), in addition to their interaction. We also used included random intercepts for participant and random slopes for distance. The model equation was, where was or , and was either or , thus:

## 1.2 Repeated sprint trial outcomes

For the repeated sprint trials we examined the time in seconds for each of the 5m sections of the 20m sprint as a dependent variable. Data was handled in long format with each row corresponding to an observation of a participants time for a 5m section for a given sprint number. We fit separate models with fixed effects for either disability or classification, and in each also included a fixed effect for the distance (i.e., section of the 20m sprint trial: 0-5m, 5-10m, 10-15m, 15-20m) and also for the sprint number (from first to tenth), in addition to their interactions. We also used included random intercepts for participant and random slopes for both distance and sprint number. The model equation was, where was either or , thus:

We also examined the blood lactate pre- and post-repeated sprint trials as a dependent variable. Data was handled in long format with each row corresponding to an observation of a participants blood lactate at either pre- or post-repeated sprint trials. We fit separate models with fixed effects for either disability or classification, and in each also included a fixed effect for the time-point (i.e., pre- or post-repeated sprint trials coded as pre=0 and post=1), in addition to their interaction. We also used included random intercepts for participant. The model equation was, where was either or , thus:

# Results

## 1.3 Sprint trial outcomes

The overall grand means and credible intervals from the models for the fixed effects (i.e., without including the random effects) for both velocity and acceleration can be seen in [Figure 1](#fig-velocity-model-plot) and [Figure 2](#fig-acceleration-model-plot), in addition to individual data, respectively for both disability and classification models. All parameters for both outcomes and both disability and classification models are also shown in [Table 1](#tbl-sprint-model). As might be expected, fixed effects in both models revealed that velocity increased as distance covered increased and the reverse pattern for acceleration which decreased as distance covered increased. Random effects in both models showed that variation in velocities increased with increasing distance covered, and also the random effects correlations suggested that those who were initially faster, or faster during certain sections of the sprint, were similarly typically faster at all other distances. Variance in acceleration was more similar over increasing distance covered as compared with velocity, and also the random effects correlations suggested that those who had initially higher acceleration showed greater declines in acceleration across all distances, though between adjacent distances there were more positive relationships.

### 1.3.1 Disability

SCI participants showed slower velocities across all distances. There was however little interaction effect between disability and distance upon velocity. SCI participants also had lower acceleration across all distances. However, there were interactions between disability and distance whereby although over the initial 0-5m distance SCI participants had lower accelerations, the difference between them and participants with other injuries decreased as distance covered increased. During the final 10-15 and 15-20m accelerations were similar between groups.

### 1.3.2 Classification

Both 4s and 5s showed similar velocities across all distances, as well as accelerations. There was little effect of classification upon either velocity or acceleration.

Table 1: Model parameter estimates for both fixed and random effects for sprint trial outcomes (velocity and acceleration).

|  | Velocity $\\(m·s^{-1})$ | | | Acceleration $\\(m·s^{-2})$ | | |
| --- | --- | --- | --- | --- | --- | --- |
| Model Term | Estimate | Lower 95% CI | Upper 95% CI | Estimate | Lower 95% CI | Upper 95% CI |
| **Disability Model** | | | | | | |
| *Fixed Effects* | | | | | | |
| Intercept | 2.32 | 2.18 | 2.46 | 1.08 | 0.98 | 1.19 |
| $Disability\_{SCI}$ | -0.26 | -0.46 | -0.06 | -0.22 | -0.38 | -0.07 |
| $Distance\_{5-10m}$ | 1.00 | 0.90 | 1.10 | -0.41 | -0.48 | -0.34 |
| $Distance\_{10-15m}$ | 1.32 | 1.19 | 1.45 | -0.84 | -0.93 | -0.76 |
| $Distance\_{15-20m}$ | 1.57 | 1.40 | 1.75 | -0.88 | -0.97 | -0.79 |
| $Disability\_{SCI}$:$Distance\_{5-10m}$ | -0.10 | -0.24 | 0.04 | 0.10 | 0.00 | 0.20 |
| $Disability\_{SCI}$:$Distance\_{10-15m}$ | -0.09 | -0.29 | 0.10 | 0.21 | 0.09 | 0.32 |
| $Disability\_{SCI}$:$Distance\_{15-20m}$ | -0.11 | -0.36 | 0.15 | 0.19 | 0.07 | 0.32 |
| *Random Effects* | | | | | | |
| $\sigma\_{Intercept}$ | 0.23 | 0.17 | 0.32 | 0.17 | 0.12 | 0.23 |
| $\sigma\_{distance5M10m}$ | 0.15 | 0.11 | 0.21 | 0.10 | 0.06 | 0.15 |
| $\sigma\_{distance10M15m}$ | 0.21 | 0.16 | 0.29 | 0.12 | 0.08 | 0.17 |
| $\sigma\_{distance15M20m}$ | 0.28 | 0.21 | 0.39 | 0.13 | 0.09 | 0.18 |
| $\rho\_{Intercept:Distance\_{5-10m}}$ | 0.69 | 0.34 | 0.90 | -0.10 | -0.53 | 0.36 |
| $\rho\_{Intercept:Distance\_{10-15m}}$ | 0.61 | 0.26 | 0.85 | -0.85 | -0.96 | -0.63 |
| $\rho\_{Intercept:Distance\_{15-20m}}$ | 0.54 | 0.16 | 0.80 | -0.79 | -0.93 | -0.52 |
| $\rho\_{Distance\_{5-10m}:Distance\_{10-15m}}$ | 0.94 | 0.83 | 0.99 | 0.39 | -0.09 | 0.75 |
| $\rho\_{Distance\_{5-10m}:Distance\_{15-20m}}$ | 0.90 | 0.74 | 0.98 | 0.47 | 0.01 | 0.79 |
| $\rho\_{Distance\_{10-15m}:Distance\_{15-20m}}$ | 0.97 | 0.90 | 1.00 | 0.88 | 0.65 | 0.99 |
| $\sigma\_{Residual}$ | 0.07 | 0.06 | 0.08 | 0.07 | 0.06 | 0.08 |
| **Classification Model** | | | | | | |
| *Fixed Effects* | | | | | | |
| Intercept | 2.17 | 2.02 | 2.32 | 0.95 | 0.84 | 1.07 |
| $Classification\_{5}$ | 0.04 | -0.20 | 0.27 | 0.04 | -0.14 | 0.21 |
| $Distance\_{5-10m}$ | 0.98 | 0.89 | 1.07 | -0.32 | -0.39 | -0.26 |
| $Distance\_{10-15m}$ | 1.33 | 1.21 | 1.45 | -0.70 | -0.80 | -0.61 |
| $Distance\_{15-20m}$ | 1.60 | 1.45 | 1.76 | -0.74 | -0.83 | -0.65 |
| $Classification\_{5}$:$Distance\_{5-10m}$ | -0.06 | -0.21 | 0.08 | -0.08 | -0.19 | 0.02 |
| $Classification\_{5}$:$Distance\_{10-15m}$ | -0.13 | -0.31 | 0.06 | -0.09 | -0.23 | 0.06 |
| $Classification\_{5}$:$Distance\_{15-20m}$ | -0.20 | -0.44 | 0.04 | -0.10 | -0.24 | 0.04 |
| *Random Effects* | | | | | | |
| $\sigma\_{Intercept}$ | 0.26 | 0.19 | 0.36 | 0.20 | 0.15 | 0.27 |
| $\sigma\_{distance5M10m}$ | 0.16 | 0.11 | 0.21 | 0.10 | 0.06 | 0.15 |
| $\sigma\_{distance10M15m}$ | 0.20 | 0.15 | 0.28 | 0.15 | 0.11 | 0.21 |
| $\sigma\_{distance15M20m}$ | 0.27 | 0.20 | 0.36 | 0.15 | 0.11 | 0.21 |
| $\rho\_{Intercept:Distance\_{5-10m}}$ | 0.73 | 0.41 | 0.92 | -0.29 | -0.67 | 0.16 |
| $\rho\_{Intercept:Distance\_{10-15m}}$ | 0.65 | 0.31 | 0.86 | -0.91 | -0.98 | -0.77 |
| $\rho\_{Intercept:Distance\_{15-20m}}$ | 0.60 | 0.24 | 0.83 | -0.87 | -0.96 | -0.69 |
| $\rho\_{Intercept:Distance\_{15-20m}}$ | 0.60 | 0.24 | 0.83 | -0.87 | -0.96 | -0.69 |
| $\rho\_{Distance\_{5-10m}:Distance\_{15-20m}}$ | 0.91 | 0.75 | 0.98 | 0.53 | 0.11 | 0.82 |
| $\rho\_{Distance\_{10-15m}:Distance\_{15-20m}}$ | 0.97 | 0.90 | 1.00 | 0.91 | 0.74 | 0.99 |
| $\sigma\_{Residual}$ | 0.07 | 0.06 | 0.08 | 0.07 | 0.06 | 0.08 |
| Note: |  |  |  |  |  |  |
| CI = credible interval |  |  |  |  |  |  |

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| Figure 1: Individual data (top row) and global grand means with distribution and 95% credible interval estimates from the expectation of the posterior predictive distribution (bottom row) for velocity by both disability, panels (A) and (B), and classification, panels (C) and (D). |

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| Figure 2: Individual data (top row) and global grand means with distribution and 95% credible interval estimates from the expectation of the posterior predictive distribution (bottom row) for acceleration by both disability, panels (A) and (B), and classification, panels (C) and (D). |

## 1.4 Repeated sprint trial outcomes

### 1.4.1 Sprint times

The overall grand means and credible intervals from the models for the fixed effects (i.e., without including the random effects) for repeated sprint times can be seen in [Figure 3](#fig-rsa-model-plot) and [Figure 2](#fig-acceleration-model-plot), in addition to individual data and participant level linear smooths, respectively for both disability and classification models. All parameters for both outcomes and both disability and classification models are also shown in [Table 2](#tbl-rsa-model).

On average, fixed effects in both models revealed that sprint number had little impact on time, however did interact with distance revealing greater increases in time for later sprints over increasing distances. Sprint number had little impact upon the initial 0-5m. Of course, trivially, time increased as distance covered increased. Random effects in both models showed, similarly to velocity in the sprint trials, that variation in times increased with increasing distance covered. Also the random effects correlations suggested that those who were initially faster at the beginning of a sprint, faster during certain sections of the sprint, or faster during a given sprint number, were similarly typically faster at all other distances and during all other sprint numbers.

#### 1.4.1.1 Disability

Both SCI and other disabilities showed similar performances in the repeated sprints, across all distances, and all sprint numbers. There was little effect of disability upon either repeated sprint times.

#### 1.4.1.2 Classification

Both 4s and 5s showed similar performances in the repeated sprints, across all distances, and all sprint numbers. There was little effect of classification upon either repeated sprint times.

Table 2: Model parameter estimates for both fixed and random effects for repeated sprint trial times.

|  | Time (seconds) | | |
| --- | --- | --- | --- |
| Model Term | Estimate | Lower 95% CI | Upper 95% CI |
| **Disability Model** | | | |
| *Fixed Effects* | | | |
| Intercept | 2.29 | 2.16 | 2.43 |
| $Disability\_{SCI}$ | 0.10 | -0.10 | 0.31 |
| Sprint Number | 0.01 | -0.01 | 0.03 |
| $Distance\_{5-10m}$ | 1.59 | 1.46 | 1.71 |
| $Distance\_{10-15m}$ | 3.01 | 2.80 | 3.23 |
| $Distance\_{15-20m}$ | 4.37 | 4.05 | 4.69 |
| $Disability\_{SCI}$:Sprint Number | 0.00 | -0.03 | 0.03 |
| $Disability\_{SCI}$:$Distance\_{5-10m}$ | 0.02 | -0.18 | 0.21 |
| $Disability\_{SCI}$:$Distance\_{10-15m}$ | 0.01 | -0.33 | 0.35 |
| $Disability\_{SCI}$:$Distance\_{15-20m}$ | -0.01 | -0.51 | 0.49 |
| Sprint Number:$Distance\_{5-10m}$ | 0.02 | 0.01 | 0.03 |
| Sprint Number:$Distance\_{10-15m}$ | 0.04 | 0.03 | 0.05 |
| Sprint Number:$Distance\_{15-20m}$ | 0.07 | 0.05 | 0.08 |
| $Disability\_{SCI}$:Sprint Number:$Distance\_{5-10m}$ | -0.01 | -0.02 | 0.01 |
| $Disability\_{SCI}$:Sprint Number:$Distance\_{10-15m}$ | -0.01 | -0.03 | 0.01 |
| $Disability\_{SCI}$:Sprint Number:$Distance\_{15-20m}$ | -0.02 | -0.04 | 0.00 |
| *Random Effects* | | | |
| $\sigma\_{Intercept}$ | 0.18 | 0.12 | 0.28 |
| $\sigma\_{Sprint Number}$ | 0.02 | 0.02 | 0.04 |
| $\sigma\_{distance5M10m}$ | 0.15 | 0.11 | 0.22 |
| $\sigma\_{distance10M15m}$ | 0.31 | 0.23 | 0.43 |
| $\sigma\_{distance15M20m}$ | 0.48 | 0.36 | 0.66 |
| $\rho\_{Intercept:Sprint Number}$ | -0.24 | -0.64 | 0.23 |
| $\rho\_{Intercept:Distance\_{5-10m}}$ | 0.41 | -0.02 | 0.75 |
| $\rho\_{Intercept:Distance\_{10-15m}}$ | 0.38 | -0.03 | 0.69 |
| $\rho\_{Intercept:Distance\_{15-20m}}$ | 0.35 | -0.06 | 0.67 |
| $\rho\_{Sprint Number:Distance\_{5-10m}}$ | 0.55 | 0.14 | 0.84 |
| $\rho\_{Sprint Number:Distance\_{10-15m}}$ | 0.62 | 0.28 | 0.85 |
| $\rho\_{Sprint Number:Distance\_{15-20m}}$ | 0.65 | 0.34 | 0.86 |
| $\rho\_{Distance\_{5-10m}:Distance\_{10-15m}}$ | 0.95 | 0.83 | 0.99 |
| $\rho\_{Distance\_{5-10m}:Distance\_{15-20m}}$ | 0.94 | 0.81 | 0.99 |
| $\rho\_{Distance\_{10-15m}:Distance\_{15-20m}}$ | 0.99 | 0.94 | 1.00 |
| $\sigma\_{Residual}$ | 0.12 | 0.11 | 0.13 |
| **Classification Model** | | | |
| *Fixed Effects* | | | |
| Intercept | 2.39 | 2.25 | 2.53 |
| $Classification\_{5}$ | -0.12 | -0.34 | 0.09 |
| Sprint Number | 0.00 | -0.01 | 0.02 |
| $Distance\_{5-10m}$ | 1.60 | 1.47 | 1.72 |
| $Distance\_{10-15m}$ | 3.01 | 2.79 | 3.23 |
| $Distance\_{15-20m}$ | 4.34 | 4.01 | 4.66 |
| $Classification\_{5}$:Sprint Number | 0.01 | -0.02 | 0.04 |
| $Classification\_{5}$:$Distance\_{5-10m}$ | -0.01 | -0.20 | 0.19 |
| $Classification\_{5}$:$Distance\_{10-15m}$ | 0.02 | -0.31 | 0.35 |
| $Classification\_{5}$:$Distance\_{15-20m}$ | 0.07 | -0.43 | 0.57 |
| Sprint Number:$Distance\_{5-10m}$ | 0.01 | 0.00 | 0.03 |
| Sprint Number:$Distance\_{10-15m}$ | 0.03 | 0.02 | 0.05 |
| Sprint Number:$Distance\_{15-20m}$ | 0.06 | 0.04 | 0.07 |
| $Classification\_{5}$:Sprint Number:$Distance\_{5-10m}$ | 0.00 | -0.01 | 0.02 |
| $Classification\_{5}$:Sprint Number:$Distance\_{10-15m}$ | 0.00 | -0.01 | 0.02 |
| $Classification\_{5}$:Sprint Number:$Distance\_{15-20m}$ | 0.00 | -0.01 | 0.02 |
| *Random Effects* | | | |
| $\sigma\_{Intercept}$ | 0.19 | 0.12 | 0.30 |
| $\sigma\_{Sprint Number}$ | 0.02 | 0.02 | 0.03 |
| $\sigma\_{distance5M10m}$ | 0.15 | 0.11 | 0.21 |
| $\sigma\_{distance10M15m}$ | 0.31 | 0.23 | 0.42 |
| $\sigma\_{distance15M20m}$ | 0.48 | 0.36 | 0.65 |
| $\rho\_{Intercept:Sprint Number}$ | -0.16 | -0.60 | 0.31 |
| $\rho\_{Intercept:Distance\_{5-10m}}$ | 0.40 | -0.04 | 0.74 |
| $\rho\_{Intercept:Distance\_{10-15m}}$ | 0.35 | -0.06 | 0.68 |
| $\rho\_{Intercept:Distance\_{15-20m}}$ | 0.33 | -0.08 | 0.66 |
| $\rho\_{Sprint Number:Distance\_{5-10m}}$ | 0.57 | 0.14 | 0.84 |
| $\rho\_{Sprint Number:Distance\_{10-15m}}$ | 0.63 | 0.26 | 0.86 |
| $\rho\_{Sprint Number:Distance\_{15-20m}}$ | 0.65 | 0.31 | 0.87 |
| $\rho\_{Distance\_{5-10m}:Distance\_{10-15m}}$ | 0.95 | 0.83 | 0.99 |
| $\rho\_{Distance\_{5-10m}:Distance\_{15-20m}}$ | 0.94 | 0.80 | 0.99 |
| $\rho\_{Distance\_{10-15m}:Distance\_{15-20m}}$ | 0.99 | 0.94 | 1.00 |
| $\sigma\_{Residual}$ | 0.12 | 0.11 | 0.13 |
| Note: |  |  |  |
| CI = credible interval |  |  |  |

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| Figure 3: Individual data with linear smooths by participant (top row) and global grand means with distribution and 95% credible interval estimates from the expectation of the posterior predictive distribution (bottom row) for repeated sprint times by both disability, panels (A) and (B), and classification, panels (C) and (D). |

### 1.4.2 Blood lactate

The overall grand means and credible intervals from the models for the fixed effects (i.e., without including the random effects) for blood lactate can be seen in [Figure 4](#fig-lactate-model-plot) in addition to individual data, respectively for both disability and classification models. All parameters for both outcomes and both disability and classification models are also shown in [Table 3](#tbl-lactate-model). As might be expected, fixed effects in both models revealed that blood lactate increased as from pre- to post-repeated sprint trials (see terms in [Table 3](#tbl-lactate-model)). Random intercepts also showed some variation in baseline blood lactate levels.

### 1.4.3 Disability

There was little difference in average blood lactate levels between those with SCI or other disabilities, nor was there a clear interaction effect suggesting both groups increased in blood lactate similarly.

### 1.4.4 Classification

Both 4s and 5s showed similar average blood lactate levels too. However, the posterior estimates were suggestive of an interaction effect little effect of classification upon either velocity or acceleration whereby 5s tended to show a greater increase in blood lactate levels post-repeated sprint trials.

Table 3: Model parameter estimates for both fixed and random effects for blood lactate pre- and post-repeated sprint trials.

|  | Blood lactate ($\\(m·L^{-1})$) | | |
| --- | --- | --- | --- |
| Model Term | Estimate | Lower 95% CI | Upper 95% CI |
| **Disability Model** | | | |
| *Fixed Effects* | | | |
| Intercept | 2.57 | 1.02 | 4.13 |
| $Disability\_{SCI}$ | -0.47 | -2.84 | 1.91 |
| Time | 5.57 | 3.49 | 7.65 |
| $Disability\_{SCI}$:Time | -0.40 | -3.48 | 2.64 |
| *Random Effects* | | | |
| $\sigma\_{Intercept}$ | 0.71 | 0.03 | 1.86 |
| $\sigma\_{Residual}$ | 2.19 | 1.64 | 2.92 |
| **Classification Model** | | | |
| *Fixed Effects* | | | |
| Intercept | 2.46 | 0.97 | 3.93 |
| $Classification\_{5}$ | -0.19 | -2.45 | 2.07 |
| Time | 4.49 | 2.52 | 6.48 |
| $classication\_{5}$:Time | 2.05 | -0.93 | 5.01 |
| *Random Effects* | | | |
| $\sigma\_{Intercept}$ | 0.70 | 0.03 | 1.81 |
| $\sigma\_{Residual}$ | 2.09 | 1.57 | 2.81 |
| Note: |  |  |  |
| CI = credible interval |  |  |  |

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| Figure 4: Individual data with linear smooths by participant (top row) and global grand means with distribution and 95% credible interval estimates from the expectation of the posterior predictive distribution (bottom row) for repeated sprint times by both disability, panels (A) and (B), and classification, panels (C) and (D). |

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