Predicting eggbeater kick performances from hip joint function testing in artistic swimming

July 25, 2019

1 Supplementary material

1.1 Appendix 1

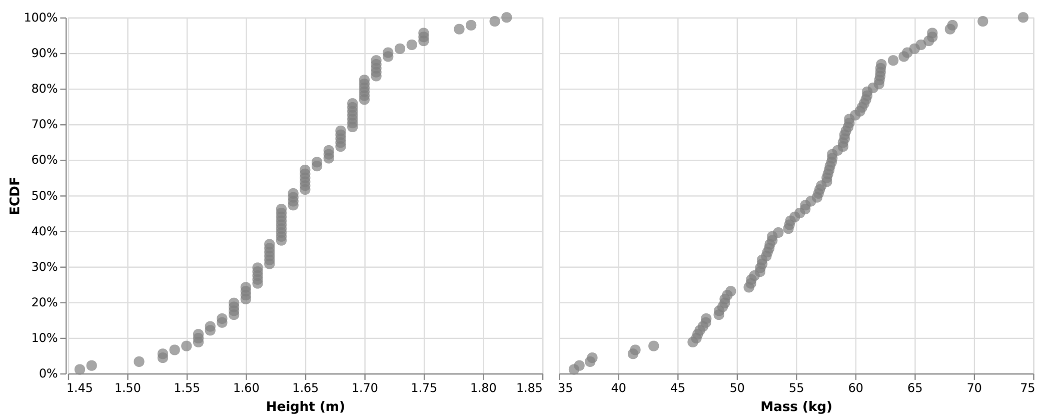

Figure 1: Empirical cumulative distribution function (ECDF) of the participants' height (left panel) and mass (right panel). The ECDF evaluated at x is defined as the fraction of data points that are $\leq x$.

1.2 Appendix 2

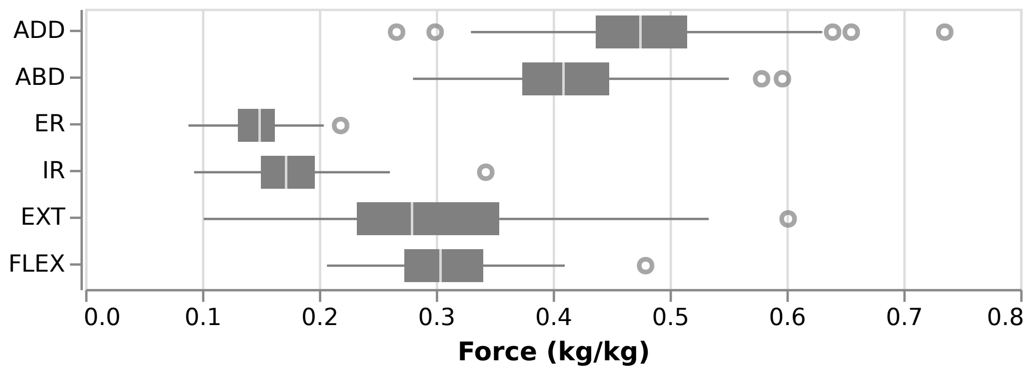

Figure 2: Tukey box plot showing the normalized force evaluated on the MVIC with median (vertical lines), first-third interquartile range (bars), minimum-maximum range (horizontal lines) and outliers (values that are > 3 standard deviations) (circles).

1.3 Appendix 3

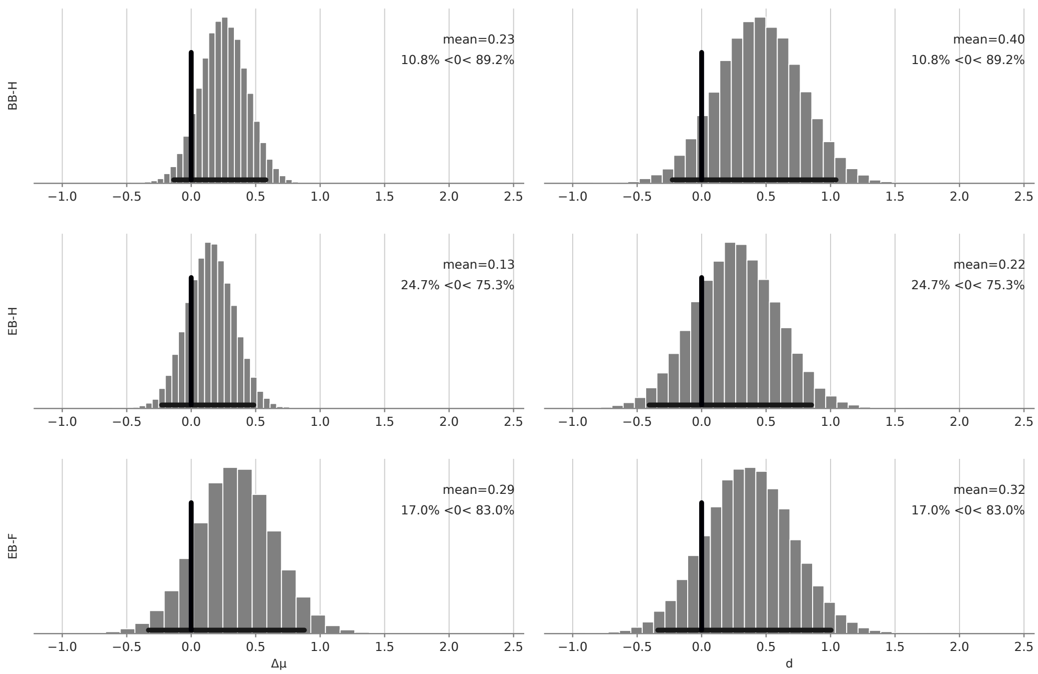

Figure 3: Posterior distributions (bars) of the mean difference (left panel) and effect size (right panel) estimated with the Bayesian model described in Kruschke [2013] with 95% HPD (horizontal lines) for every sport-specific test. Mean and proportions relative to zero (vertical lines) are displayed in the top right of each plot.

1.4 Appendix 4

Two case studies were defined to illustrate how our model can be used to help define conditioning goals. In a first simulation, we evaluated the projected performance in BB-H with an independent increase (10%) in each hip strength variable or a decrease in hip imbalance. In a second simulation, we computed the minimum strength increase and imbalance decrease required to achieve an improvement of 0.5 points (F_{obj}) in BB-H. We used a multi-objective and unconstrained optimization problem solved by an evolutionary algorithm (Speed-constrained Multi-objective Particle Swarm Optimization [Nebro et al., 2009]) adapted to non-continuous functions. The first objective aimed to achieve a score as close as possible to F_{obj}. The second and third objectives aimed to minimize the change in forces and imbalances, respectively. Each variable was weighted by the normalized impact factor, estimated previously from the feature importance, to ensure a fast convergence of the evolutionary algorithm toward a globally optimal solution. The bounds of the parameters were set to allow up to 50% increase in force and 100% decrease in imbalance. The first simulation (10% increase in strength and 10% decrease in imbalance) highlights two different scenarios to improve BB-H performance for two swimmers (Figure 4). A 10% increase in each hip strength test for swimmer A (Figure 4, left panel) is slightly beneficial for the predicted performance only in FLEX (+0.04 points), while a 10% decrease in imbalance seems to have a greater effect especially in ABD (+0.23) and IR (+0.13). Alternatively, in swimmer B (Figure 4, right panel), a similar increase in strength is beneficial in ER (+0.10) while the decrease in imbalance has no effect on predicted performance. Interestingly, a 10% increase in ABD hip strength decrease slightly the predicted performance in swimmer B (−0.03). Therefore, swimmer A should reduce her imbalance in ABD and IR, whereas swimmer B should increase her strength in ER.

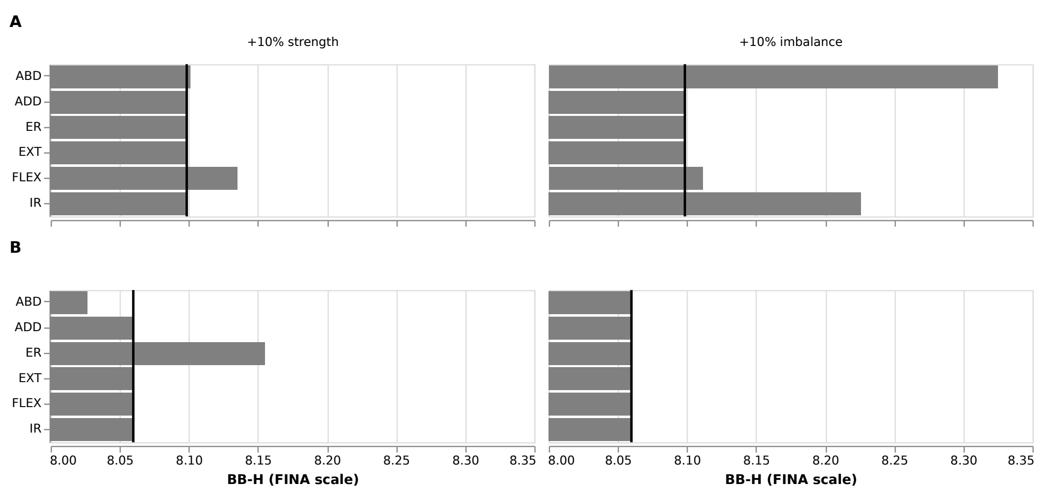

Figure 4: First simulation with a 10% increase in strength (left panel) and a 10% decrease in imbalance (right panel) in each individual hip strength test (y-axis) and its impact on the BB-H performance prediction (x-axis) for two random swimmers (A and B). The baseline prediction is also displayed (vertical lines).

Even if the second simulation (minimum strength increase and imbalance decrease required to achieve an improvement of 0.5 points) provides some similarities with the first one, different strategies appear as this method takes into account the interactions between the input variables (Figure 5). First, and similarly with the first simulation, the optimization tried to reduce the left-right imbalance in swimmer A (Figure 5, left panel) in ABD (−4.62%), FLEX (−2.97%) and IR (−1.24%) but also in ER (−2.40%), ADD (−1.22%) and EXT (−1.02%), while imbalance remains the same in swimmer B (Figure 5, right panel). Second, and in contrast with the first simulation, the optimization increased strength in ABD (+5.36 kg), ADD (+4.36 kg), ER (+0.35 kg) and EXT but also in FLEX (+2.41 kg) in swimmer A and in ADD (+5.56 kg) and FLEX (+2.94 kg) in swimmer B. Some large decrease in strength occur in EXT (−7.51 kg) and IR (−3.05 kg) in swimmer B.

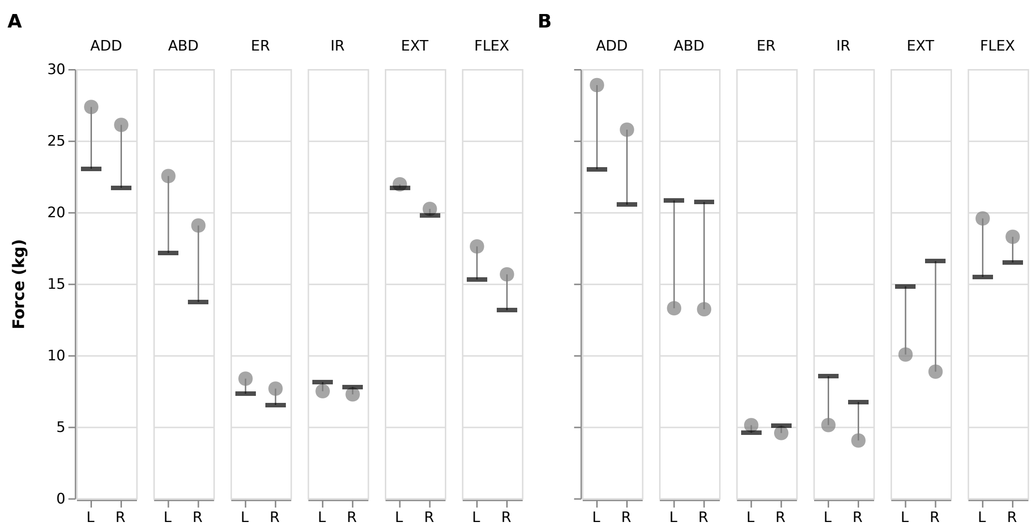

Figure 5: Second simulation with the optimal set of hip strength of both left (L) and right (R) legs (points) to achieve an improvement of 0.5 point in BB-H for two random swimmers (left panel: A, right panel: B). The baseline values are also displayed (horizontal lines).

References

John K Kruschke. Bayesian estimation supersedes the t test. *J. Exp. Psychol. Gen.*, 142(2):573–603, May 2013.

A J Nebro, J J Durillo, J Garcia-Nieto, C A Coello Coello, F Luna, and E Alba. SMPSO: A new PSO-based metaheuristic for multi-objective optimization. In *2009 IEEE Symposium on Computational Intelligence in Multi-Criteria Decision-Making(MCDM)*, pages 66–73, March 2009.