Statistical algorithms and issues arising during the development of a hand force-plate sensor system for false start detection in competitive sprinting

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Abstract:
A series of experimental studies carried out by the Human Performance Laboratory at the University of Limerick have established that the first response all athletes make when executing a sprint start is to push the ground with their hands. This presentation reports on the statistical issues that arose during the development and testing of a new false start detection system using a prototype hand force-plate system.

The new hand plate sensor system developed at the University of Limerick represents a major shift in design of sprint start detection technology because it fundamentally changes the way in which a false start is detected. This new system examines changes in the ground reaction force under the hands using a custom built hand plate sensor and signal processing algorithm. Our research has revealed that in all cases, the change in force at the hand ground interface precedes the response in the blocks by between 40 to 100 ms. Consequently, starting-block based systems are not capable of detecting an athlete's first response to the start signal and this is a fundamental drawback in the technology currently in use.

Elite sprinters ($n = 20$) executed 3 to 4 sprint starts and their reaction times were simultaneously determined by (i) an approved IAAF start system; (ii) accelerometers placed on the starting blocks; and (iii) a prototype hand force-plate detection system. An IAAF certified official starter administered the starts. An algorithm based on CUSUM scores was developed to process the accelerometer readings from the blocks in place of the less sensitive threshold method used by the IAAF system. A signed score algorithm was developed to determine reaction times based on hand force plate detector. Graphical comparison of these determinations of reaction time were made using Bland-Altman plots showing linked replicates, (R package MethComp, Carstensen et al. 2015). The statistical reliability of these detection systems is discussed.