The Biomechanics of an Optimized Sprint Start

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Background

Sprinting

Track and field sprinting demands exceptional precision, with victories often determined by milliseconds. The critical nature of every step and moment underscores the importance of optimal technique, particularly in the starting block setup

Previous Research

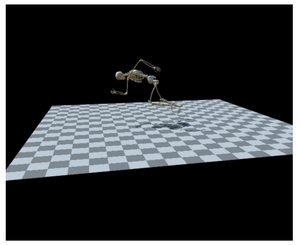
Previous research has extensively explored various aspects of the block start. Researchers have taken on the block start in many different ways such as looking at torso angle in the set position, forces produced with the foot pedals at different angles and the difference the moving the blocks makes [1]. It has been revealed that many athletes begin with their feet positioned closer together than optimal[1,2,3]. Studies indicate that the most effective block spacing occurs when the distance between the feet is approximately 45% of the athlete's leg length. However, these studies typically assume a standard two-foot distance from the front starting block pedal to the starting line, without examining the impact of varying front block placements [1,2]. Given all of this previous research there appears to be a lack of knowledge in how adjusting the front starting block forward and backs affects the overall sprint start.

Subject performing a start

Hypothesis

There is no statistically significant difference in the velocity of athletes when track starting blocks are set at 45%, 57.5%, and 70% of the athletes' leg length away from the starting line, with a consistent spacing of 45% of the leg length between the blocks. However, placing the blocks closer to the starting line results in a further second-step distance.

OpenCap app recording a subject performing a start



OpenCap web interface of

Software Used

OpenCap

OpenCap is an open-source platform developed at Stanford for motion capture that is being used with 4 ipad cameras. The subject performs the start while the devices record the action. The data from different camera angles are synchronized and analyzed to create a 3D model of the motion.

OpenSim

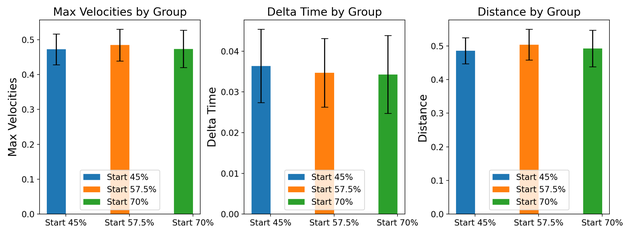
OpenSim is an open-source software platform used for modeling, simulating, and analyzing the musculoskeletal system. It allows for the calculation of joint angles, moments and position from motion capture data, enabling detailed analysis of the sprint start.

Python

Python is used to take the analyzed data from the motion capture and make meaning of it though averages and graphs

Methods

Subjects were first asked to complete a 400 meter jog followed by a set of dynamic stretches for 20m. Once the warmup was complete the subjects leg length, height and weight were noted. The subject then set up their blocks in preferred position and it was recorded. Next, the subject would begin their six starts in random order being recorded by OpenCap. They performed starts twice with the front block at either 45%, 57.5% and 70% of the subjects leg length away from the line. The space between blocks was kept at 45% of the athletes leg length as deemed optimal by other studies. Each subject was given a 6 minute rest between each start. The starts were then downloaded and taken into OpenSim where reports on inverse dynamics and body kinematics were generated. These reports were then taken into a python in which they were evaluated. The main metrics for any significant differences that was looked at was forward velocity and the position and time of the center of mass at the second step [3]. Other metrics were evaluated to see if there was any other underlying changes in each of the starting positions.



These graphs show the normalized means and standard error for velocity, total time and distance

Findings

Pilot data suggests the middle start is optimal, though not statistically significant with 4 subjects. Even small differences are practically significant in a sport measured in milliseconds.

Future

Test at least 8 more athletes to strengthen our statical findings. It is then hoped to find an effective way to share the findings to a broader audience.

References

1. Cavedon, V., Sandri, M., Pirlo, M., Petrone, N., Zancanaro, C., & Milanese, C. (2019). Anthropometry-driven block setting improves starting block performance in sprinters. PLoS ONE, 14(3), e0213979. https://doi.org/10.1371/journal.pone.0213979

2. Chen, Y., Wu, K.-Y., Tsai, Y.-J., Yang, W.-T., & Chang, J.-H. (2016). The kinematic differences of three types of crouched positions during a sprint start. Journal of Mechanics in Medicine and Biology, 16(7), 1650099. https://doi.org/10.1142/S0219519416500998

3. Valamatos, M. J., Abrantes, J. M., Carnide, F., Valamatos, M.-J., & Monteiro, C. P. (2022). Biomechanical performance factors in the track and field sprint start: A systematic review. International Journal of Environmental Research and Public Health, 19(7), 4074. https://doi.org/10.3390/ijerph19074074

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