Biomechanical Analysis of a Sprint Start

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Introduction

Our presentation will cover the Key Elements of our project. They will be presented along with the methods, results and discussion of each analysis.
Key Elements

- Phase Description
- Critical Feature Checklist
- Literature Reviews
- Anatomical Analysis
- Velocity/Acceleration Profile
- Phase Timing Analysis
- Video Kinematic Analysis
Phase Description

This Key Element describes the performance objectives of each phase of the Sprint Start.

- We broke down the sprint start into four distinct phases.
- Each phase has a precise beginning and ending point.
- The phases were determined using a video of an Olympic sprinter coming out of the blocks.
Phase Description

Phase 1 – “On Your Mark”

- The major joint contributions are primarily the shoulders due to having to hold the pressure from the legs against the hands.
- The beginning of this phase was when the feet and hands are placed and knees are touching the ground.
- The end occurred when the body becomes motionless waiting for the "Set" signal.
Phase Description

Phase 2 – “Set”

- The “Set” phase uses the hips, knees and shoulders. The hips and knees press the pelvis upwards while the hands and arms support the upper body.
- This phase begins when the knees and hips are pressed upwards at "Set" Signal.
- When the body becomes motionless waiting for the "On Your Marks" Signal is the end of the phase.
Phase Description

Phase 3 – “Go”

- In phase 3 the rear knee and ankle as well as the extension of the rear hip are being used.
- The beginning of Phase 3 is when the body begins accelerating in a linear motion on the "Go" signal.
- It ends when the rear foot leaves the block.
Phase Description

Phase 4 – “First Step/Front Leg Extension"

- The final phase utilizes the ankle, knee and hip of the front leg and the lower back is used to pull the body upwards. The shoulders and arms are now only supporting the arms weight as well as all inertia created by the motion.

- When the rear leg is in a forward motion. Front arm is in a forward motion is the beginning of the phase.

- The phase ends when the front leg is fully extended. Rear arm is extended above body.
The checklist was created using the description for each phase. They were applied to three different videos of three different experienced athletes. The videos obtained were from YouTube.com and were of Olympic, College and High School sprinters.
Critical Features Checklist

Each phase had been analyzed further and we found that there were particular positions in which the body needed to be in.

Each were given a point value for how well they completed each phase.

- 1 - Incomplete
- 2 - Almost Incomplete
- 3 - Near Complete
- 4 - Almost Complete
- 5 - Complete
## Critical Features Checklist

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>&quot;On Your Marks&quot;</th>
<th>Olympic</th>
<th>College</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet placed in blocks</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Front knee is even with the starting line but off the ground</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Rear knee is rested on the ground</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Body is leaned forward with shoulders over the starting line</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Hands placed in proper alignment behind the line</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
## Critical Features Checklist

<table>
<thead>
<tr>
<th>Phase 2</th>
<th>&quot;Set&quot;</th>
<th>Olympic</th>
<th>College</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Front leg creates a 90° angle</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Rear leg creates approximately 120°</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Body is leaning forward with most of the body weight on hands</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Arms are straight at a 75° over starting line</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Hips come up higher than shoulders</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>
# Critical Features Checklist

<table>
<thead>
<tr>
<th>Phase</th>
<th>&quot;Go&quot;</th>
<th>Olympic</th>
<th>College</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td></td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Extension of the rear leg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arms come off the ground</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Body is parallel to ground</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Head is tucked</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase 4</td>
<td>&quot;First Step/Front Leg Extension&quot;</td>
<td>Olympic</td>
<td>College</td>
<td>High School</td>
</tr>
<tr>
<td>---------</td>
<td>---------------------------------</td>
<td>---------</td>
<td>---------</td>
<td>-------------</td>
</tr>
<tr>
<td></td>
<td>Front foot pushing off the block</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Front leg in full extension</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Rear foot flexed towards shin</td>
<td>5</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Rear leg flexed</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Straight line between foot and head along body</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Body is at a 40° angle to the ground</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Front arm is at 90° between upper and lower arm</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Rear arm is at a 180° and extended above body</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Head is tucked</td>
<td>5</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>
When we evaluated the Olympic athlete we ranked them with all “5’s” due to the expertise and precise execution of all determined aspects of each phase.

We found that our college athlete wasn’t as proficient as the Olympic athlete and therefore didn’t rank as high.

The high school athlete lacked in some key aspects of each phase. We assumed that this is due to the lack of experience.
Literature Review

Breaking down a sprint start is easier done with the understanding of what is essential for an efficient start. Literature on sprint starts helped determine what phases were used for the rest of the project.

We did ten literature review that ranged from journal articles, book sources, online sources and online videos.
Anatomical Analysis

Our next step in the pursuit of the understanding of what’s happening during a sprint start was to determine what muscles are being used in each phase.
Anatomical Analysis

This was done by creating a spreadsheet with each phase having its own heading and a table devoted to it.

In the tables each major joint section was determined and each muscle was listed and its appropriate joint action and position, the muscles that were active and the contraction type associated with that muscle.
Anatomical Analysis

<table>
<thead>
<tr>
<th>Joint Name</th>
<th>Joint Action/ Postion</th>
<th>Active Muscles</th>
<th>Contraction Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head/Neck</td>
<td>None</td>
<td>Sternocleidomastoid, Splenius</td>
<td>All Isometric</td>
</tr>
<tr>
<td>Trunk</td>
<td>Lumbar Flexion</td>
<td>Rectus Abdominus, External Obliques, Internal Obliques, Transverse Obliques, Erector Spinae, Quadratus Lumborum</td>
<td>Bilateral: Isometric, Isometric, Exhalation/Concentric, Eccentric, Eccentric</td>
</tr>
</tbody>
</table>

Due to the length of the complete table only a small selection was chosen to represent how we completed the analysis.
Anatomical Analysis

The anatomical analysis allowed us to see what was happening at the skeletal level of the body.
Velocity/Acceleration Profile

To demonstrate the velocity/acceleration of a sprint start we had two sprinters each perform a thirty meter sprint out of the sprinting blocks.
Velocity/Acceleration Profile

We timed each sprinter at five meter intervals, with a total of six, to show how they accelerated throughout their sprint.

For each phase time we calculated the average section velocity and then the average section acceleration.

We then presented our findings in table and chart form.
Velocity/Acceleration Profile

For our first sprinter we noticed that his speed increased over each interval.

This lets us believe that this is a very well trained and well conditioned sprinter.

We believe from the data that the thirty meters might not have been long enough for him to reach top speed.
Velocity/Acceleration Profile

With our second sprinter we noticed that his intervals decreased as he progressed down the track.

Between the fourth and fifth cones he slowed down showing that within those five meters he reached his top speed and began to slow.
Velocity/Acceleration Profile

Sprinter 1
Velocity/Acceleration Profile

Sprinter 2

Velocity Profile

Acceleration Profile
Phase Timing Analysis

The idea behind our phase timing analysis was to video tape two different athletes sprint starts out of sprinting blocks.

We wanted to see what differences there were, using the number of frames, between each sprinter in each of the four phases of the sprint start.

The phases were determined due to the nature in the posture and arrangement of body parts for the sprinter.
Phase Timing Analysis

Two different male athletes were utilized in which both with very different athletic backgrounds.

Sprinter one had little sprinting background where as sprinter two had a considerable amount more.

The instructions given to the sprinters were to complete a sprint start at normal race speed.
Phase Timing Analysis

The phase timing analysis was done by using a Panasonic PV-DV73 camera.
The software program used was Sony Vegas Movie Studio Platinum.
Our results were calculated in the number of frames and time between each phase.
Phase Timing Analysis

Phase Timing Comparison

- Springer 1 Time (sec)
- Sprinter 2 Time (sec)
Phase Timing Analysis

We found that Sprinter one was quicker out of the blocks over all with a total time of 3.80 seconds compared to Sprinter two of 4.03 seconds.

It took him 67 frames, or 2.23 seconds, to finish phase one where as Sprinter two took 68 frames, or 2.27 seconds.
Phase Timing Analysis

Phase two was quicker with Sprinter one with 36 frames, or 1.20 seconds, where as Sprinter two took 42 frames, or 1.40 seconds.

The third phase was much closer between the two sprinters with only a one frame difference.

In the last phase Sprinter two was quicker by a frame, though over all had a slower time.
The video kinematics analysis we created is a motion tracking analysis, joint angle measurement and a segment inclination measurement.

The motion tracking was done at each phase with a stick figure representing the sprinters movement out of the blocks.
Video Kinematic Analysis

For our joint angle measurement we chose to measure the knee angle of the front leg of the sprinter in each phase.

We decided to do a segment inclination measurement of the hip movement of each phase.
Video Kinematic Analysis

The motion tracking analysis we took a screen shot of each phase of the sprinter from our recorded video and then copied the photo into Microsoft Publisher.

Next we applied the appropriate line segments over each body segment of the copied photo in order to create the sprinter.

This process was continued for each of the four total phases.

We represented each joint with small circles.
Video Kinematic Analysis

We decided to measure the angle of the knee of the front leg of the sprinter because it is a critical joint movement for this particular skill.

We took the stick figures from our motion tracking analysis and measured the appropriate knee angle of each of the four phases.
Video Kinematic Analysis

We used the same four screen shots from the video to determine the position and angle of the hips.

Both sprinters were used for comparison of the orientation in which the hips moved through space.

A triangle was used to represent the hips and the base of the triangle is supposed to represent the crest of the hips.
Video Kinematic Analysis

At each phase we observed where the hips were and how they were tilted and moved the triangle to best represent this. A dotted line was then used to show the path the hips moved between phases. A parallel line was then placed at the lowest point of the base of the triangle to help determine the angle at which the hips are at in that particular phase.
Video Kinematic Analysis

Motion Tracking

Phase 1  Phase 2  Phase 3  Phase 4
Video Kinematic Analysis

Knee Joint Angle Measurement

Phase 1  Phase 2  Phase 3  Phase 4
Video Kinematic Analysis

Segment Inclination Measurement of the Hip

Sprinter 1

Sprinter 2
Video Kinematic Analysis

From observing the three different video kinematic analyses we were able to have a better understanding of the sprint start. In turn this enables us to help sprinters and us in explaining the most efficient method for a sprint start. The motion tracking analysis allowed us to see the critical movements of each phase the sprinter goes through.
Final Thoughts

If there would have been more time we would have liked to apply all that we had learned to create an efficient movement pattern for each participant.

Next, we would apply the increased efficiency movement pattern to the participants.
Final Thoughts

We gained an immense amount of knowledge about the sprint start and if time were allowed, much more could have been obtained.
Last Slide

Have a great break!