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New Perspectives on Analyzing and Interpreting Base Running Efficiency: An IMU Foot Pod Methodological Case Approach

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Abstract

This article presents a practical framework for implementing, collecting, and interpreting inertial measurement unit (IMU) foot pod data to improve diagnostic understanding of baseball base running mechanics. Linear sprinting is used as a baseline, whereas the home-to-second-base sprint trial is used to examine how that capacity is expressed when athletes negotiate curvilinear running demands. The purpose is not to establish generalized performance outcomes, but to illustrate how IMU-derived spatiotemporal variables may be interpreted across successive base running segments in applied settings. Three competitive baseball players were selected from a larger dataset of n = 54 base runners tested using the same protocol with distinct home-to-second-base performance profiles as follows: the fastest case (Player X), an intermediate case (Player Y), and the slowest case (Player Z) were selected based on total home-to-second-base time. The cases were selected purposively to demonstrate the application of the IMU interpretation framework, including ground contact time (GCT), stride length (SL), push-off acceleration, and impact acceleration. Particular emphasis is placed on how curvilinear demands alter inside- and outside-foot function, and how segment-to-segment comparisons may help practitioners identify phases in which base runners maintain, reorganize, or lose mechanical efficiency. Compared with broader velocity-based approaches, the IMU framework provides complementary step-level information that may help practitioners generate hypotheses about how base runners organize movement across linear and curvilinear segments. These examples are intended to demonstrate a workflow for applied interpretation rather than to establish causal mechanisms. As a result, IMU foot pod analysis may offer practitioners a structured and portable method for interpreting curvilinear sprint mechanics, yet these case examples should be understood as descriptive rather than prescriptive.

Keywords: monitoring; mechanics; sprinting; curvilinear running

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1. Introduction

Linear sprint mechanics provide a useful baseline for understanding a base runner's straight-line acceleration and maximal speed capacity. However, running multiple bases in baseball requires athletes to express that capacity while negotiating curved trajectories and redirecting the center of mass around the bases. During curvilinear running, athletes must coordinate body lean, foot placement, and force application to maintain velocity while limiting excessive braking. These requirements can produce foot-specific differences between the inside and outside limbs, particularly as athletes enter and progress through the curved portion of the path. Therefore, comparing linear and curvilinear sprinting provides a useful framework for identifying how base runners maintain, reorganize, or lose mechanical efficiency across multiple-base running tasks.

Previous curvilinear-sprinting research has shown that curvilinear sprinting differs from linear sprinting in ground contact time (GCT), stride length (SL), and inter-foot asymmetries during sprint acceleration and maximal velocity phases [1–3]. Recently, researchers have further emphasized the neuromuscular specificity of curvilinear sprinting. Sašek et al. [4] examined the relationships between lower-limb strength, strength asymmetries, linear sprinting, and curvilinear sprinting in student-athletes in team sports. They reported very large associations between hip adductor and abductor strength and 30 m curvilinear sprint performance to the left (r = −0.75 and −0.71), while hip abductor strength symmetry was also related (r = −0.71, $p < 0.001$) to faster curvilinear sprint times. It seems that curvilinear sprinting may be influenced by hip strength; therefore, the interpretation of inside–outside foot mechanics during base running should be considered within the broader context of lower-limb strength, asymmetry, and task-specific curvilinear running demands. Moreover, specifically in baseball base running, Martinez-Rodriguez et al. [5] further reported that inside–outside foot asymmetries are segment-dependent, with group-level patterns varying across phases of the home-to-second route. Together, these findings support the need to examine base running as a task-specific movement pattern rather than as a simple extension of straight-line sprinting. Importantly, asymmetry should be interpreted in relation to task demands and segment context rather than automatically treated as dysfunction.

Although prior curvilinear-sprinting studies provide important kinetic and kinematic context, they do not provide a practitioner-oriented foot pod workflow for baseball base running. One portable and cost-effective technology that could be used in gaining a better understanding of multiple base running and inside–outside foot mechanics are inertial measurement units (IMUs), in the form of foot pods. Such technology can enable detailed step-by-step analysis of spatiotemporal variables, including GCT, SL, impact acceleration, and push-off accelerations [6,7]. The novelty of this article is not the use of the inertial measurement unit (IMU) foot pod technology alone, but the organization of these variables into a base running-specific interpretative workflow. Unlike timing-only-based analyses, this framework complements segment-specific base running time and speed data with foot-specific spatiotemporal and acceleration-derived analyses. The intended contribution is therefore a practical model for translating wearable sensor outputs into applied understandings about entering, negotiating, and exiting the curve during base running.

The aim is not to generalize performance outcomes but to describe how practitioners may interpret IMU-derived spatiotemporal data within applied baseball environments. Implicit in this approach is a deeper understanding of the determinants and differences between linear-single base and curvilinear-multiple base running mechanics, which in turn can be used to inform specialized exercise prescription based on these attributes.

2. Collecting Base Running Data Using IMU Foot Pod Technology

IMU foot pods (42 × 47 × 3.4 mm; Plantiga Technologies, Vancouver, BC, Canada) were used to describe inside–outside foot mechanics by recording accelerometer and gyroscope quantifying motion in the X, Y, and Z planes (see Figure 1). The foot pods were secured within custom insoles placed under each base runner's foot to maintain consistent positioning throughout sprint testing [8].

Figure 1. IMU sensor inserted in the insoles.

The reliability of the IMU foot pod measures used in this article have been established and published previously [8]. Between-session absolute reliability was acceptable for the variables of interest, with coefficients of variation ranging from 0.8% to 9.9% for linear measures and from 1.2% to 9.9% for curvilinear measures. Relative reliability was also acceptable, with intraclass correlation coefficients ranging from 0.75 to 0.99 for linear measures and from 0.77 to 0.97 for curvilinear measures. In addition, Dasso et al. [9] examined the validity of foot-mounted IMU systems with a 3D motion-capture during maximal 10 m linear sprints and reported an acceptable level of agreement between the two technologies. Between the reported variables, SL demonstrated a wide level of agreement, and peak velocity and instantaneous velocity demonstrated moderate level of agreement. The baseball-specific curvilinear application used in this study has not yet been independently validated against 3D motion capture or floor-embedded force plates. Accordingly, the acceleration-derived interpretations in this article should be considered exploratory and hypothesis-generating within this context. Linear and curvilinear sprints were completed during the same session over a total distance of 54.7 m (home to second-base regulation distance of 54.7 m). Linear and curvilinear sprints were completed during the same testing session over a total distance of 54.7 m. The linear trial was completed first to establish an unfatigued straight-line baseline before the more technically constrained home-to-second-base sprint condition. The same order was used for all players to standardize comparisons across sprint conditions. Before testing, base runners completed a standardized dynamic warm-up focused on the lower extremity as detailed in Martínez-Rodríguez et al. [8]. Two maximal trials were performed for each sprint condition, with 3 min of recovery between trials, and 10 min between test types were taken to avoid fatigue [8,10]. For the home-to-second-base trial, participants started from a stealing lead-off stance at home plate with the front foot positioned on home plate, then rounded first base and continued through second base. The linear 54.7 m sprint began from the same starting stance but followed a straight path. All runs were completed on turf while wearing baseball-specific footwear, and base runners were instructed to maintain maximal effort through the finish line to avoid deceleration before the endpoint.

The 54.7 m linear sprint was selected as the comparison condition for the home-to-second-base trial for three reasons. First, it matched the total distance covered from home to second base and therefore provided a gameplay-relevant assessment of straight-line sprint capacity. Second, linear sprint ability contributes to curvilinear running performance [11]. In this way, the linear sprint represented straight-line sprint capacity, whereas the curvilinear trial reflected how that capacity was expressed while negotiating the turn around first base.

Each trial was also recorded with an iPad camera at 1080p resolution and 30 frames per second from a lateral view. After data collection, the pods were docked and uploaded to the Plantiga cloud for subsequent processing. Video footage was used to determine step counts for the 27.4 m (home to first distance) and 54.7 m (home to second-base distance) portions of both sprint conditions, and those step counts were aligned with the corresponding IMU signals in Plantiga Explore. The GPS device used sampled data at 10 Hz using a high-precision chipset (VX Sport, Wellington, New Zealand). Details of the GPS can be found in Martínez-Rodríguez et al. [12]. GPS-derived timestamps were used to identify when each base runner crossed the 13.7 m and 41.1 m distance markers at the same timestamp provided by the Plantiga software (version: 2026.05.26.a0ca0f7) as players wore a GPS unit during the sprints [13]. Segment boundaries were then manually identified with the masking tool to isolate each portion of the sprint from the full activity trace. All performance outcomes were ultimately obtained through the Plantiga Explore platform and the data were stored on their password-encrypted cloud servers.

Eight kinematic and spatiotemporal metrics were extracted from the Plantiga cloud for analysis as follows: inside- and outside-foot GCT, SL, average impact acceleration and average push-off acceleration. For the home-to-second-base trial, base runners ran counterclockwise around the first base. Therefore, the left foot functioned as the inside foot and the right foot as the outside foot during curve negotiation. Within this framework, GCT and SL describe the spatiotemporal organization of each step, whereas push-off acceleration and impact acceleration provide applied indicators of propulsive output and braking/stabilization demand, respectively. Variables were calculated using the manufacturer's proprietary signal-processing algorithms, which identify foot strike and toe-off events based on accelerometer and gyroscope signatures. Collectively, these variables provide insight into how base runners generate and apply force during sprinting. Descriptions for these variables are detailed in Martínez-Rodríguez et al. [8].

The following sections focus on the linear and curvilinear differences between segments (i.e., changes in spatiotemporal characteristics from the previous segment) as quantified by the foot pods. To help explain the potential reasons for the increases or decreases in speed observed in each player, the authors also included GPS-derived speed and distance data collected simultaneously with the foot pod data (see Figure 2). Within this framework, segmental comparisons were interpreted as indicators of mechanical reorganization across the sprint. Importantly, a recent group-level study by Martinez-Rodriguez et al. [5] provided a useful reference pattern for inside- vs. outside-foot asymmetry, but the case examples in this article are intended to illustrate that individual base runners may not always conform to that average profile. Practitioner considerations are made and must be interpreted in the context of being examples in how diagnostic information could be potentially used.

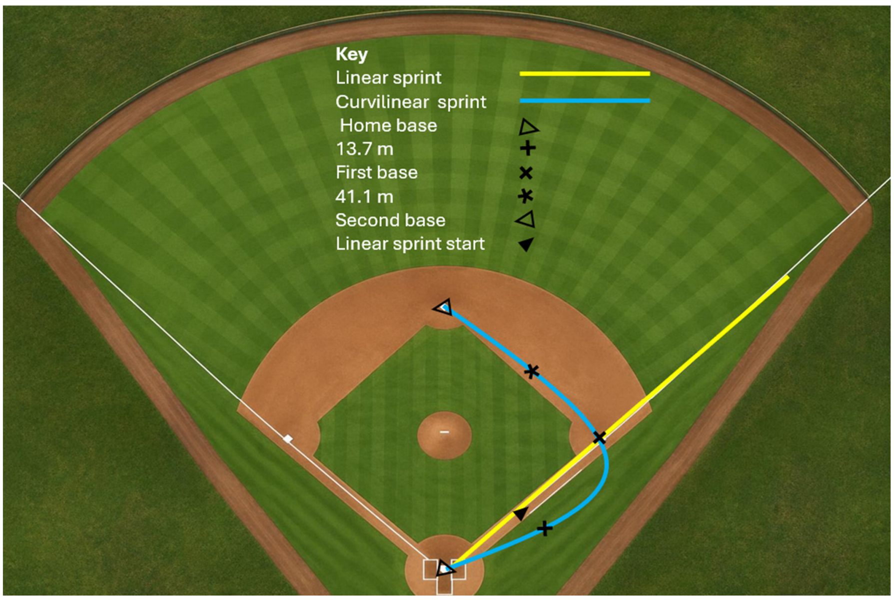

Figure 2. Home to second base and linear sprint segments.

3. Analyzing and Interpreting Linear Base Running Mechanics

Three competitive base runners (X, Y, and Z) were selected from a larger dataset of n = 54 base runners from a baseball academy in Puerto Rico. They were tested using the same protocol with distinct home-to-second-base performance profiles noted as follows: the fastest case, an intermediate case, and the slowest case based on total home-to-second-base time. The players were not selected to represent population-level performance norms, and no inferential comparison between players was intended. The cases were selected purposively to demonstrate the application of the IMU interpretation framework, including ground contact time (GCT), stride length (SL), push-off acceleration, and impact acceleration. The 54.7 m sprint was divided into four equal 13.7 m segments, consistent with previous base-running analyses [14]. The four segments were thought indicative of:

- L1 (0–13.7 m)—early-phase acceleration;
- L2 (13.7–27.4 m)—transitional acceleration;
- L3 (27.4–41.1 m)—maximal speed;
- L4 (41.1–54.7 m)—ability to maintain maximal speed—speed endurance.

The averaged linear inside–outside foot data for each of the four variables across the four segments is reported in Table 1, which summarizes foot-specific mechanical characteristics across the four linear sprint segments. Because the linear sprint did not impose curve-specific directional demands, foot differences were interpreted as individual tendencies rather than inside–outside curve effects.

Table 1. Mechanical characteristics during linear sprint segments for inside and outside foot and % change between segments for Players X, Y, and Z.

Seg	Player X			Player Y			Player Z		
	Inside Foot (% Change)	Outside Foot (% Change)	% Asym	Inside Foot (% Change)	Outside Foot (% Change)	% Asym	Inside Foot (% Change)	Outside Foot (% Change)	% Asym
Average GCT (ms)									
L1	105	98	−6.67	125	121	−3.59	195	186	−4.36
L2	79 (−25%)	77 (−21%)	−2.53	99 (−21%)	99 (−18%)	0.00	184 (−6%)	176 (−5%)	−4.09
L3	75 (−5%)	68 (−12%)	−8.67	99 (0%)	100 (1%)	0.50	185 (1%)	167 (−5%)	−9.46
L4	77 (3%)	67 (−1%)	−12.3	102 (3%)	95 (−5%)	−6.86	185 (0%)	178 (7%)	−3.25
Average SL (m)									
L1	2.77	2.72	−1.81	2.63	2.59	−1.52	2.73	2.65	−2.93
L2	3.82 (38%)	3.76 (38%)	−1.57	3.74 (42%)	3.55 (37%)	−5.08	3.35 (23%)	3.37 (27%)	0.59
L3	4.09 (7%)	3.98 (6%)	−2.69	3.79 (1%)	3.80 (7%)	0.26	3.49 (4%)	3.51 (4%)	0.57
L4	4.18 (2%)	4.04 (2%)	−3.35	3.75 (−1%)	3.79 (−0.3%)	1.06	3.56 (2%)	3.67 (5%)	3.00
Average push-off acceleration (g)									
L1	19.2	17.9	−7.02	13.1	13.9	5.54	11.0	12.1	9.34
L2	23.6 (23%)	23.4 (31%)	−0.72	16.2 (24%)	15.2 (9%)	−6.23	14.7 (34%)	14.4 (19%)	−2.24
L3	25.3 (7%)	25.6 (9%)	1.17	16.1 (−1%)	15.2 (0%)	−5.34	13.7 (−7%)	14.3 (−1%)	4.00
L4	25.6 (1%)	26.3 (3%)	2.70	15.1 (−6%)	15.2 (0%)	0.59	12.7 (−7%)	12.6 (−12%)	−1.41
Average impact acceleration (g)									
L1	16.7	19.2	12.6	18.8	17.8	−5.26	23.4	19.9	−14.7
L2	23.0 (38%)	25.9 (35%)	11.0	25.9 (38%)	27.8 (56%)	6.83	25.7 (10%)	20.9 (5%)	−18.6
L3	22.9 (−0.4%)	29.7 (15%)	22.8	27.3 (5%)	27.5 (−1%)	0.87	24.9 (−3%)	20.1 (−4%)	−19.2
L4	27.1 (18%)	30.6 (3%)	11.5	28.0 (3%)	29.2 (6%)	4.17	22.7 (−9%)	23.0 (14%)	1.00

Note: Seg = segments; Asym = Asymmetry% change = (next segment − previous segment)/previous segment × 100. Asymmetry symbol = negative value means asymmetry to the inside foot.

The use of IMU-derived step metrics in the present linear sprint analysis is supported by previous sprint-specific validation and application research. de Ruiter and van Dieën [15] demonstrated that IMUs can be used to obtain SL and step length during maximal sprint acceleration from 30 m and 60 m sprint times, sup-porting the use of wearable IMU sensors for step-by-step sprint analysis. de Ruiter et al. [16] later extended this work by validating SL estimates during maximal linear overground sprint acceleration using foot-mounted IMUs. In addition, van den Tillaar et al. [17] compared step-by-step sprint kinematics from an IMU-based system with force plate data during a 50 m sprint, further supporting the use of IMU approaches for analyzing sprint mechanics across successive steps. Therefore, the linear sprint da-ta in the present article provide a relevant baseline from which curvilinear base-running adjustments can be interpreted.

3.1. Ground Contact Time (GCT)

- GCT decreased from L1 to L3 in all players, reflecting the expected transition from early acceleration to maximal velocity running;
- Player X had the lowest GCTs (inside foot: 75–105 ms; outside foot: 67–98 ms) across all segments, particularly in L3 and L4, consistent with efficient force application at high speed;
- Player Z maintained substantially longer GCTs (35–60%) across all segments, with limited reduction beyond L1, suggesting constraints in force production at higher running speeds [18];
- As expected for linear sprinting, inside–outside foot asymmetries in GCT are generally small, though Player X had slightly larger negative asymmetries in later segments, possibly reflecting individual running mechanics rather than systematic directional bias.

3.2. Stride Length

- All players increased SL progressively (L2–L1: 22–42%; L3–L2: 1–7%; and L4–L3: 2–5%) from L1 to L4, reflecting the typical acceleration-to-higher-velocity transition, where SL increases as running speed rises [5];
- Player X achieved the greatest absolute SL (L1: 2.72 to L4: 4.18 m), especially in L3 and L4, and may indicate an effective translation of force into horizontal displacement;
- Player Z's SL remained comparatively limited (L1: 2.65–L4: 3.67 m) across all segments, reinforcing their reduced maximal speed capability and horizontal displacement;
- Inside–outside SL asymmetries were minimal and inconsistent, supporting the initial assumption of symmetry in straight-line sprinting.

3.3. Push-Off Acceleration

- Push-off acceleration increased from L1 to L3 in all players, with Player X achieving substantially higher (22–52%) values than Players Y and Z throughout;
- Player X also maintained high push-off acceleration into L4 (L1 vs. L4: 33–47%; L2 vs. L4: 8–12%; and L3 vs. L4: 1–3%), which may indicate superior speed endurance and the ability to sustain propulsive force at near-maximal speed;
- Player Z demonstrated both lower peak values (L1: 13–43%; L2: 5–38%; L3: 6–45%; and L4: 16–52%) and a plateauing or decline in later segments, consistent with reduced push-off acceleration and speed maintenance capacity [19];
- As with other variables, push-off acceleration asymmetries remain small overall, reinforcing the expectation of mechanical symmetry during linear sprinting.

3.4. Impact Acceleration

- Impact acceleration generally increased with segment progression, reflecting higher running velocities;
- Player X exhibited higher impact accelerations in later segments (L3: 0.4–55%; L4: 3–62%), likely a consequence of greater force transmission associated with high-speed sprinting [20];

- While most asymmetries remained small, greater variability (15–19%) was noted for impact acceleration than other metrics, suggesting it may be more sensitive to individual landing strategies even in linear sprinting.

3.5. Linear Sprint Transition

To evaluate how the player transitions from one segment to the next, calculating the difference between each segment (see Table 1) provides a clear indication of whether the base runner is changing strategies to adjust the body across the segments, which were illustrated in Martínez-Rodríguez et al. [13]:

- L2-L1—ability to advance from initial acceleration mechanics into transitional sprint patterns;
- L3-L2—ability to progress from accelerating to establishing maximal sprinting mechanics;
- L4-L3—ability to maintain stable spatiotemporal patterns after reaching maximal sprinting mechanics.

Overall, the data highlight distinct individual strategies in how each athlete progresses from early acceleration to maximal velocity and then attempts to maintain linear sprint mechanics.

3.5.1. Transition from Early to Transitional Acceleration (L2–L1)

Across all players, this transition is characterized by the largest mechanical adjustments, consistent with the shift from initial acceleration mechanics to more upright sprinting patterns.

- *Ground contact time (GCT)* decreased substantially for all players, particularly Players X (−25% and −21% for the inside and outside foot, respectively) and Y (−21% and −18%), and may indicate a greater rate of force development application as velocity increases. Player Z showed smaller reductions, suggesting a more conservative acceleration strategy;
- *Stride Length (SL)* increased largely in this phase for all players, most notably in Players X (38% and 38%) and Y (42% and 37%) (>1.0 m), suggesting effective conversion of horizontal force into forward displacement;
- *Push-off and Impact Accelerations* increased markedly in Players X (inside foot: 23%; outside foot: 31%) and Z (inside foot: 34%; outside foot: 19%), inferring more aggressive forces being imparted into the ground. For Player Y, greater impact acceleration combined with reduced push-off acceleration may warrant follow-up because it suggests increased loading without a parallel increase in propulsive output.

Interpretation: L2–L1 is the most mechanically demanding transition. Players differ in how they balance propulsion and stride reorganization, with Players X and Y demonstrating more explosive acceleration profiles versus Player Z.

3.5.2. Transition to Maximal Speed Mechanics (L3–L2)

This transition reflects the shift from acceleration to the establishment of maximal sprinting mechanics.

- *Ground contact time (GCT)* changes are minimal for Player Y and Z, with values close to zero or slightly negative, and may indicate stabilization of contact timing. Conversely, Player X had −5% and −12% for the inside and outside foot, respectively. This change may indicate rapid force generation for maximal speed transition;
- *Stride length (SL)* continued increasing, but to a much smaller extent than in L2–L1, consistent with nearing maximal velocity;

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- *Push-off acceleration* trends diverge: Player X (7% and 9%) had positive changes, Player Y (−1% and 0%) remained relatively constant, and Player Z (−7% and −1%) showed negligible or negative changes. Player X may increase propulsion transitioning to max speed;
- *Impact acceleration* changes were consistent for the most part across Player X, Y and Z's inside foot, suggesting players manage the transition to top speed similarly.

Interpretation: By L3, players are largely refining rather than restructuring sprint mechanics. Player X continues to increase propulsion, while Players Y and Z appear to prioritize mechanical stability over further propulsion gains.

3.5.3. Ability to Maintain Maximal Sprint Mechanics (L4–L3)

The final transition assesses speed endurance and the capacity to maintain stable mechanics after reaching maximal speed.

- *Ground contact time (GCT)* changes were small and consistent, and may reflect either maintenance or slight deterioration, depending on the player and foot;
- *Stride length (SL)* changes were minimal, with Player Y showing slight reductions and Players X and Z maintaining or modestly increasing SL;
- *Push-off acceleration* trends diverge: Player X (1% and 3%) had positive changes, Player Y (−6% and 0%) tended to decrease, specifically for the inside foot, and Player Z (−7% and −12%) showed negligible or negative changes. Player X may increase propulsion when transitioning to maintain speed;
- *Impact acceleration* responses vary substantially, suggesting individual differences in how base runners coordinate landing mechanics and strategies to absorb load impact during this phase.

Interpretation: L4–L3 revealed each player's ability to maintain maximal speed. Player X for the most part maintained relatively stable mechanics, whereas Players Y and Z showed more pronounced signs of mechanical decay that we assume to be reduced propulsion.

4. Analyzing and Interpreting Curvilinear Base Running Ability

In Table 2, the home to second-base distance has been divided into four curvilinear sprint (C) segments, and the GCT, SL, push-off acceleration, and impact acceleration for each curvilinear distance quantified via IMU foot pods:

- C1 (home plate—13.7 m)—initial acceleration preparing for the curvilinear phase;
- C2 (13.7 m—first base)—curvilinear initiation;
- C3 (first base—41.1 m)—curvilinear finalization;
- C4 (41.1 m—second base)—curve exit and reacceleration toward second base.

Table 2 summarizes the inside–outside foot kinematic and kinematic responses of three baseball players across four curvilinear sprint segments (C1–C4) from home to second base. The table reports GCT, SL, push-off acceleration, impact acceleration, and corresponding asymmetry values for each segment, allowing changes in foot-specific mechanics to be compared across the curvilinear running task.

Table 2. Kinematic characteristics during curvilinear sprint segments for inside and outside foot and % change between segments for Players X, Y, and Z.

	Player X			Player Y			Player Z		
	Inside Foot (% Change)	Outside Foot (% Change)	% Asym	Inside Foot (% Change)	Outside Foot (% Change)	% Asym	Inside Foot (% Change)	Outside Foot (% Change)	% Asym
Average GCT (ms)									
C1	125	98	−21.6	144	139	−3.47	193	197	1.78
C2	84 (−33%)	72 (−27%)	−14.2	121 (−16%)	114 (−18%)	−6.17	189 (−2%)	182 (−8%)	−3.69
C3	92 (10%)	83 (15%)	−9.78	135 (12%)	129 (13%)	−4.44	199 (5%)	183 (1%)	−8.27
C4	89 (−3%)	80 (−4%)	−10.1	119 (−12%)	111 (−14%)	−6.69	193 (−3%)	185 (1%)	−3.89
Average stride length (m)									
C1	2.61	2.62	0.38	2.68	2.68	0.00	2.47	2.41	−2.43
C2	3.68 (41%)	3.53 (35%)	−4.08	3.55 (32%)	3.64 (36%)	2.47	3.22 (30%)	3.25 (35%)	0.92
C3	3.63 (−1%)	3.63 (3%)	0.00	3.43 (−3%)	3.63 (−0.3%)	5.51	3.17 (−2%)	3.22 (−1%)	1.55
C4	3.79 (4%)	3.68 (1%)	−2.90	3.63 (6%)	3.66 (1%)	0.82	3.45 (9%)	3.55 (10%)	2.82
Average push-off acceleration (g)									
C1	20.0	18.4	−8.13	12.2	12.0	−1.40	11.5	10.6	−8.23
C2	24.4 (22%)	21.5 (17%)	−12.0	14.1 (16%)	14.8 (23%)	4.34	14.5 (26%)	11.4 (8%)	−21.3
C3	22.3 (−9%)	21.0 (−2%)	−6.0	13.5 (−4%)	13.2 (−11%)	−2.22	13.0 (−10%)	11.9 (4%)	−8.82
C4	22.2 (−0.5%)	21.3 (1%)	−3.9	12.8 (−5%)	11.8 (−11%)	−8.27	11.3 (−13%)	11.8 (−1%)	4.40
Average impact acceleration (g)									
C1	19.5	21.9	11.0	16.3	17.8	8.48	24.2	19.0	−21.6
C2	27.5 (41%)	32.1 (47%)	14.3	20.7 (27%)	22.9 (29%)	9.79	24.1 (−0.4%)	22.8 (20%)	−5.5
C3	29.0 (5%)	29.6 (−8%)	1.89	21.3 (3%)	21.8 (−5%)	2.56	22.4 (−7%)	20.6 (−10%)	−7.9
C4	31.3 (8%)	28.1 (−5%)	−10.3	19.4 (−9%)	24.0 (10%)	19.0	21.3 (−5%)	19.1 (−7%)	−10.1

Note: Asym = Asymmetry; % change = (next segment − previous segment)/previous segment × 100. Asymmetry symbol = negative value means asymmetry to the inside foot.

4.1. Ground Contact Time (GCT)

Across all players, outside-foot GCT was consistently shorter (2–22% asymmetry) than inside-foot GCT, particularly during the early and middle curvilinear segments (C1–C3). This effect was most pronounced in Player X, who demonstrated large negative asymmetries (up to −22% in C1), and may indicate a rapid unloading of the outside foot during curve-entry and mid-curve segments (C2–C3). Player Y displayed smaller but consistent asymmetries (3–6%), while Player Z showed minimal or occasionally reversed asymmetry in early segments. C1 occurred before the main curved portion of the route; asymmetry in this segment may reflect the base runner's approach strategy, including whether they begin preparing for the curve earlier or opt for late entry until they are closer to first base. Importantly, asymmetry generally diminished by C4 in all players, suggesting a convergence of foot function due to the linear nature of reacceleration towards second base became the priority.

4.2. Stride Length

SL asymmetry was highly individualized. Player X displayed relatively symmetric SL across all segments (0–4%), despite notable GCT asymmetries. Player Y showed increasing outside-foot dominance in C3, whereas Player Z demonstrated slightly longer outside-foot strides later in the sprint (C3–C4). Collectively, it seems that curvilinear sprinting asymmetry is not necessarily expressed through SL, but rather theorized through how force is applied and managed during stance.

4.3. Push-Off Acceleration

Push-off acceleration highlighted the functional role of the inside foot as the primary propulsive foot during curvilinear sprinting. Player X demonstrated consistently greater inside-foot push-off acceleration (4–12%), with especially large asymmetries in C2 for Player Z (−12%), coinciding with curvilinear initiation. In contrast, Player Y showed smaller asymmetries (1–8%) and even a reversal in C2, suggesting a different force-sharing strategy or possibly a less aggressive entry into the curve. Across all players, push-off asymmetry tended to reduce in later segments, aligning with the transition toward reacceleration in the latter stages of the curved path that has more linearized sprint approach in reaching second base.

4.4. Impact Acceleration

Impact acceleration asymmetry was more variable and segment-dependent. Players X and Y generally exhibited greater impact accelerations on the outside foot during early segments (2–14%), consistent with increased braking and lateral loading demands during curve negotiation. Player Z displayed the opposite trend in early segments, with substantially higher inside-foot impacts in C1 and C2 (6–22%), which may indicate altered load acceptance mechanics, mediolateral shifts in center of mass position, or greater disruption during curve negotiation. By C4, impact acceleration asymmetry increased again in Players X and Y and may reflect reacceleration demands and potentially fatigue-related changes in foot loading strategies.

4.5. Curvilinear Sprint Transition

As using the same segment-to-segment comparison approach applied to the linear sprint, the curvilinear trial was examined across C1–C4 (see Table 2). This approach provides a clearer indication of how the players adapt to counteract curvilinear demands through each curvilinear segment. The following interpretations are descriptive and should be read as plausible mechanical explanations rather than confirmed causal mechanisms. The description of each curvilinear sprint segment differences is as follows:

- C2–C1—data from these segments reflected how sprint mechanics adjust when entering the curve;
- C3–C2—data from these segments reflected how mechanics changed from curve entry into turn negotiation after rounding first base;
- C4–C3—data from these segments reflected how the base runner adjusts mechanics while exiting the curve and progressing toward second base.

4.5.1. Entering the Curve (C2–C1)

When athletes transition from linear sprinting into the curve:

- *Ground contact time (GCT)* decreased across all three players. Player X decreased by −33% and −27%, Player Y by −16% and −18%, and Player Z by −2% and −8% for the inside and outside foot, respectively. This may indicate an increase in speed into the curve entry by an increase in rapid force generation;
- *Stride length (SL)* increased for both inside and outside foot (30–41%) across all players. These increases suggest that athletes maintained or built speed rather than braking on curve entry;
- *Push-off acceleration* increased markedly, especially in Players X by 22% and 17% and Y by 16% and 23% for the inside and outside foot respectively, and Player Z inside foot by 26%. This reflects greater propulsive demand to initiate curvilinear sprinting. However, Player Z may be redirecting and depending on the inside foot for propulsion entering to the curve compared to Players X and Y;
- *Impact acceleration* increased, most notably in the outside foot (20–47%), implying greater loading as athletes reorient force vectors into the curve.

Interpretation: Entry into the curve is characterized by aggressive mechanical adjustments, prioritizing propulsion and high rate of force development to maintain momentum while initiating directional change.

4.5.2. Mid-Curve Transition (C3–C2)

As base runners reorganize mechanics while fully rounding first base:

- *Ground contact time (GCT)* increased slightly in Player X (10% and 15%) and Y (12% and 13%), which may indicate that these athletes are slowing down signaling time spent in stance for stabilization and redirection;
- *Stride length (SL)* generally decreased or plateaued (−0.3% to −3%) for all the players, suggesting a slowing down or maintenance of speed through the curve to accommodate the feet on the way to the left side (i.e., to cover less space when changing direction);
- *Push-off acceleration* declined across all players (−2% to −11%), although Player Z showed a small outside-foot increase. These changes may suggest a lower propulsive emphasis during mid-curve negotiation;
- *Impact acceleration* tended to mix, decreasing in the outside foot and increasing in the inside foot. These changes may reflect force attenuation and redirection with the inside foot whilst running the curve.

Interpretation: This phase may represent a period of mechanical stabilization, where reduced push-off acceleration and slightly longer ground contact times could indicate a shift toward path negotiation rather than further propulsion. Furthermore, it is likely a mechanical stabilization period, where reduced push-off acceleration and slightly longer GCT could indicate a shift toward stabilization and curvilinear path negotiation rather than pure propulsion.

4.5.3. Exiting the Curve Toward Second Base (C4–C3)

As base runners transition back toward linear sprinting:

- *Ground contact time (GCT)* changed slightly during this transition for Player X and Y, while Player Z showed a smaller and more stable response (−3% and 1%). These changes suggest that contact timing became shorter or remained relatively stable during the transition from curve exit toward second base;
- *Stride length (SL)* increased slightly in all players, with the largest increases in Player Z (9% and 10%) and smaller increases in Players X (4% and 1%) and Y (6% and 1%). This may suggest that Player Z depends greater on running in a more linear path to reaccelerate after curve negotiation compared to Players X and Y;
- *Push-off acceleration* remains reduced in all players except for Player X outside foot (1%). This may suggest that base runners may not have increased propulsive magnitude during curve exit. Instead, reacceleration toward second base may have been supported by other mechanical adjustments, such as changes in stride timing, foot placement, or force orientation as the sprint path became straighter;
- *Impact acceleration* patterns diverge Player X increased inside foot (8%) and decrease outside foot (−5%). Players Y decrease inside foot (−5%) and increase outside foot (10%). Player Z decrease both foot impacts (−5% and −7%). These changes may indicate athlete-specific strategies during re-acceleration toward the second base.

Interpretation: Curve exit is marked by a progressive re-establishment of linear sprint mechanics, with athletes lengthening stride, decreasing stance time, and preparing for maximal linear acceleration toward second base.

5. Inside- vs. Outside-Foot Asymmetry Diagnostics

Foot roles change during curvilinear sprinting, as asymmetry between the inside and outside foot was calculated for each variable. In this context, asymmetry should not automatically be interpreted as dysfunction. Instead, segment-specific asymmetry may reflect a reorganization to curvilinear task demands, particularly when the inside foot assumes greater stabilization demands and the outside foot contributes more to propulsion. The purpose of this analysis is therefore not to classify base runners as symmetrical or asymmetrical in a simplistic sense, but to illustrate how the magnitude and direction of asymmetry may help practitioners interpret foot-specific mechanical strategies across base-running segments. Importantly, although group-level data have suggested a predominant outside-foot push-off acceleration pattern during curvilinear sprinting [5], the present case examples indicate that individual base runners may depart from that average pattern, reinforcing the need for case-by-case interpretation of foot-specific mechanical strategies.

Percent asymmetry between inside and outside feet provides insight into the inside- and outside-foot mechanical balance of a base runner during linear and curvilinear sprinting. It reflects how the inside and outside foot contribute to exerting force on the ground to propel the body forward. Positive values indicate greater values for the outside foot, whereas negative values indicate greater values for the inside foot. Larger percentages therefore represent greater mechanical asymmetry between the two feet during the curvilinear running task. Asymmetry is calculated using the following formula provided by the manufacturer:

$$\text{Asymmetry (\%)} = \frac{(R - L)}{\max(R, L)} \times 100$$

This formula normalizes asymmetry to a higher foot value, allowing for a standardized interpretation of mechanical asymmetry. A value near 0% indicates minimal difference between the inside and outside feet for that specific variable. Larger values indicate greater foot-specific differences, with the direction of the value identifying whether the higher value occurred on the inside or outside foot.

In the context of curvilinear base running, percent asymmetry helps identify whether the mechanical demands of rounding a base increase or decrease foot differences. Curvilinear sprinting imposes inside- and outside-foot loading differences; thus, asymmetry values often shift relative to the segment. For example, an asymmetry value of 10% indicates that the inside and outside feet differed by approximately 10% for that specific variable within that segment. No baseball-specific IMU asymmetry threshold has been established; thus, values approaching or exceeding 10% were used only as a practical flag to guide visual inspection and practitioner discussion. This threshold was not treated as a statistical cutoff or diagnostic criterion. Therefore, percent asymmetry provides a variable-specific indicator of foot-to-foot difference during base running. Table 3 describes the asymmetry values observed during curvilinear sprinting and compares them with the matched linear baseline segments. This comparison helps determine whether curvilinear running amplifies, reduces, or reverses the asymmetry already present during linear sprinting for each player.

Across all three players, curvilinear sprinting segments (C1–C4) consistently altered both the magnitude and direction of asymmetry relative to their matched linear segments (L1–L4). However, the nature of these changes was highly player- and variable-specific. Relative to the baseball-specific reference pattern reported by Martínez-Rodríguez et al. [8], the present case examples mentioned that the direction and magnitude of asymmetry can vary by base runner, variable, and segment. Overall, curvilinear running did not uniformly increase asymmetry across all variables. Instead, it produced selective amplification, attenuation, or even reversal of asymmetry, depending on the mechanical variable considered and the individual runner.

Table 3. Percent asymmetry comparison between inside and outside foot across three different players.

Seg	Player X			Player Y			Player Z		
	Inside Foot	Outside Foot	% Asym	Inside Foot	Outside Foot	% Asym	Inside Foot	Outside Foot	% Asym
				Average GCT (ms)					
C1	**125**	**98**	**−21.6**	144	139	−3.47	193	197	1.78
L1	105	98	−6.67	125	121	−3.59	195	186	−4.36
C2	**84**	**72**	**−14.2**	121	114	−6.17	189	182	−3.69
L2	79	77	−2.53	99	99	0.00	183	176	−4.09
C3	**92**	**83**	**−9.78**	135	129	−4.44	199	183	−8.27
L3	75	68	−8.67	99	100	0.50	185	167	−9.46
C4	**89**	**80**	**−10.1**	119	111	−6.69	193	185	−3.89
L4	77	67	−12.3	102	95	−6.86	184	178	−3.25
				Average stride length (m)					
C1	2.61	2.62	0.38	2.68	2.68	0.00	2.47	2.41	−2.43
L1	2.77	2.72	−1.81	2.63	2.59	−1.52	2.73	2.65	−2.93
C2	3.68	3.53	−4.08	3.55	3.64	2.47	3.22	3.25	0.92
L2	3.82	3.76	−1.57	3.74	3.55	−5.08	3.35	3.37	0.59
C3	3.63	3.63	0.00	3.43	3.63	5.51	3.17	3.22	1.55
L3	4.09	3.98	−2.69	3.79	3.80	0.26	3.49	3.51	0.57
C4	3.79	3.68	−2.90	3.63	3.66	0.82	3.45	3.55	2.82
L4	4.18	4.04	−3.35	3.75	3.79	1.06	3.56	3.67	3.00
				Average push-off acceleration (g)					
C1	20.0	18.4	−8.13	12.2	12.0	−1.40	11.5	10.6	−8.23
L1	19.2	17.9	−7.02	18.8	17.8	−5.26	11.0	12.1	9.34
C2	**24.4**	**21.5**	**−12.0**	14.1	14.8	4.34	**14.5**	**11.4**	**−21.3**
L2	23.6	23.4	−0.72	16.2	15.2	−6.23	14.7	14.4	−2.24
C3	22.3	21.0	−6.01	13.5	13.2	−2.22	13.0	11.9	−8.82
L3	25.3	25.6	1.17	16.1	15.2	−5.34	13.7	14.3	4.00
C4	22.2	21.3	−3.88	12.8	11.8	−8.27	11.3	11.8	4.40
L4	25.6	26.3	2.70	15.1	15.2	0.59	12.7	12.6	−1.41
				Average impact acceleration (g)					
C1	**19.5**	**21.9**	**11.0**	16.3	17.8	8.48	**24.2**	**18.9**	**−21.6**
L1	**16.7**	**19.2**	**12.6**	13.1	13.9	5.54	**23.3**	**19.9**	**−14.7**
C2	**27.5**	**32.1**	**14.3**	**20.7**	**22.9**	**9.79**	24.1	22.8	−5.48
L2	**23.0**	**25.9**	**11.0**	25.9	27.8	6.83	**25.7**	**20.9**	**−18.6**
C3	29.0	29.6	1.89	21.3	21.8	2.56	22.4	20.6	−7.86
L3	**22.9**	**29.6**	**22.8**	27.3	27.5	0.87	**24.9**	**20.1**	**−19.2**
C4	**31.3**	**28.1**	**−10.3**	**19.4**	**24.0**	**19.0**	**21.3**	**19.1**	**−10.1**
L4	**27.1**	**30.6**	**11.5**	28.0	29.2	4.17	22.7	23.0	1.00

Note: Seg = segments; Asym = Asymmetry. Absolute asymmetry values ≥ 10% were highlighted to assist visual identification of the segments and variables with more pronounced inside- and outside-foot differences.

5.1. Ground Contact Time (GCT)

The asymmetry magnitude of Player X was consistently greater in curvilinear segments than matched linear segments (e.g., C1 −22% vs. L1 −7%), consistent with a stronger stabilization role of the inside foot when rounding the base. Player Y also showed greater inside-foot asymmetry in curvilinear segments (e.g., C2 −6% vs. L1 0%), though to a lesser extent than Player X. Player Z differences between curvilinear and linear segments were modest, suggesting less segment-specific reorganization of GCT. In summary, curvilinear segments generally increased inside-foot dominance (more negative asymmetry) relative to linear segments, particularly in Players X and Y. Player Z showed smaller and more stable asymmetries, with minimal C–L divergence.

Interpretation: Curvilinear sprinting tends to increase temporal loading on the inside foot, but the magnitude of this adaptation is highly individual.

5.2. Stride Length

SL changes between matched C and L segments rarely exceeded ~3–5%. Some curvilinear segments showed slightly greater asymmetry, but this was inconsistent in both direction and magnitude. In summary, SL asymmetry was small across all conditions, regardless of segment type. Curvilinear sprinting did not systematically amplify asymmetry compared with linear sprinting.

Interpretation: SL appears to be relatively preserved across linear and curvilinear conditions, suggesting that runners modulate other mechanical variables (timing and force application) rather than spatial stride parameters when rounding a base.

5.3. Push-Off Acceleration

Player X often demonstrated larger inside-foot dominance in the curvilinear segments compared with linear segments (e.g., C2 −12% vs. L2 −0.7%). Player Y displayed mixed responses, with both amplification and reduction in asymmetry in curvilinear segments. Player Z exhibited large curvilinear increases in push-off asymmetry magnitude in some cases (e.g., C2 −21% vs. L2 −2%). In summary, push-off acceleration showed greater sensitivity to curvilinear task demands than SL. Contrary to group-level expectations of a dominant outside-foot propulsive strategy, all three players frequently showed increased inside-foot push-off dominance during curvilinear segments.

Interpretation: Rather than a uniform outside-foot propulsion strategy, the data indicated individualized propulsion solutions, with some runners increasing reliance on the inside foot during curvilinear acceleration demands.

5.4. Impact Acceleration

The curvilinear segments of Player X and B often showed greater asymmetry (either increased or reversed) compared with linear segments and may indicate altered impact attenuation strategies. Player Z maintained strong inside-foot dominance in many segments, but with variable amplification during curvilinear running. In summary, impact acceleration produced the most frequent $\geq$10% asymmetry values across the 24 player-by-segment comparisons, the direction of asymmetry frequently differing between players, particularly in the curvilinear segments.

Interpretation: Impact acceleration appeared sensitive to the changing demands of curvilinear sprinting, with step-to-step variability suggesting repeated adjustments in foot placement, loading, and force attenuation as athletes maintained their trajectory around the base.

6. Curvilinear vs. Linear Diagnostics

In this section the linear and curvilinear same-segment-variables are compared to show how much a specific spatiotemporal variable can change, when linear sprinting and curvilinear base running variables are compared. This comparison helps determine the magnitude to which curvilinear sprinting demands alter linear mechanical characteristics. The percent difference is calculated as follows:

$$\text{Percent difference } (\%) = \frac{\text{Curvilinear} - \text{Linear}}{\text{Linear}} \times 100$$

A value close to 0% indicates that the base runner maintained similar mechanical characteristics in both linear and curvilinear sprinting, which may indicate strong transfer of linear mechanics into curvilinear sprinting. Positive or negative values indicate the degree of mechanical alteration that may be associated with curvilinear demands. These differences highlight how each base runner adapts mechanically when navigating curvilinear direction changes. For example, a +5% value for GCT means the runner exhibited slightly longer GCT during a specific curvilinear segment compared to the same linear segment. Mechanically speaking, the percent difference comparisons provide insight into how the curvilinear demands disrupt or reorganize the base runner's usual linear sprint strategy.

The key spatiotemporal and mechanical variable changes when base runner's same-segment linear and curvilinear sprinting is compared; they are shown as percent differences in Table 4. The observations from this table are summarized below.

Table 4. Percent difference comparison between linear and curvilinear sprint across three different players.

Seg	Player X				Player Y				Player Z			
	Inside Foot	**% Diff**	**Outside Foot**	**% Diff**	**Inside Foot**	**% Diff**	**Outside Foot**	**% Diff**	**Inside Foot**	**% Diff**	**Outside Foot**	**% Diff**
Average GCT (ms)												
C1	125	17.4	98	0.00	144	13.7	139	13.9	193	−0.77	197	5.48
L1	105		98		125		121		195		186	
C2	84	6.73	72	−6.02	121	20.4	114	14.1	189	3.22	182	3.63
L2	79		77		99		99		183		176	
C3	92	20.4	83	19.1	135	30.3	129	25.3	199	7.54	183	8.84
L3	75		68		99		100		185		167	
C4	89	15.0	80	17.6	119	15.8	111	16.0	193	4.50	185	3.85
L4	77		67		102		95		184		178	
Average stride length (m)												
C1	2.61	−5.95	2.62	−3.75	2.68	1.88	2.68	3.42	2.47	−10.00	2.41	−9.49
L1	2.77		2.72		2.63		2.59		2.73		2.65	
C2	3.68	−3.73	3.53	−6.31	3.55	−5.21	3.64	2.50	3.22	−3.96	3.25	−3.63
L2	3.82		3.76		3.74		3.55		3.35		3.37	
C3	3.63	−11.92	3.63	−9.20	3.43	−9.97	3.63	−4.58	3.17	−9.61	3.22	−8.62
L3	4.09		3.98		3.79		3.80		3.49		3.51	
C4	3.79	−9.79	3.68	−9.33	3.63	−3.25	3.66	−3.49	3.45	−3.14	3.55	−3.32
L4	4.18		4.04		3.75		3.79		3.56		3.67	

Table 4. *Cont.*

Seg	Player X				Player Y				Player Z			
	Inside Foot	**% Diff**	**Outside Foot**	**% Diff**	**Inside Foot**	**% Diff**	**Outside Foot**	**% Diff**	**Inside Foot**	**% Diff**	**Outside Foot**	**% Diff**
	Average push-off acceleration (g)											
C1	20.0	4.07	18.4	2.87	12.2	−43.0	12.0	−39.2	11.6	5.06	10.6	−13.3
L1	19.2		17.9		18.8		17.8		11.0		12.1	
C2	24.4	3.50	21.4	−8.56	14.1	−13.7	14.8	−2.87	14.5	−1.43	11.4	−23.1
L2	23.6		23.4		16.2		15.2		14.7		14.4	
C3	22.3	−12.6	21.0	−19.9	13.5	−17.4	13.2	−14.2	13.0	−4.86	11.9	−18.1
L3	25.3		25.6		16.1		15.2		13.7		14.2	
C4	22.2	−14.2	21.3	−20.8	12.8	−16.3	11.8	−25.5	11.3	−12.0	11.8	−6.08
L4	25.6		26.3		15.1		15.2		12.7		12.6	
	Average impact acceleration (g)											
C1	19.5	15.3	21.9	13.5	16.3	21.5	17.8	24.6	24.2	3.37	18.9	−5.15
L1	16.7		19.2		13.1		13.9		23.4		19.9	
C2	27.5	17.6	32.1	21.4	20.7	−22.7	22.9	−19.5	24.1	−6.23	22.8	8.75
L2	23.0		25.9		25.9		27.8		25.7		20.9	
C3	29.0	23.7	29.6	−0.1	21.3	−24.7	21.8	−23.0	22.4	−10.7	20.6	2.36
L3	22.9		29.6		27.2		27.5		24.9		20.1	
C4	31.3	14.6	28.1	−8.6	19.4	−36.2	24.0	−20.0	21.3	−6.73	19.1	−18.4
L4	27.1		30.6		28.0		29.2		22.7		23.0	

Note: Seg = segment.

6.1. Ground Contact Time (GCT)

Player X showed positive percent differences ≥10% in four of eight foot-by-segment GCT comparisons, while Player Y showed positive percent differences ≥10% in all eight foot-by-segment GCT comparisons. These findings suggest that curvilinear sprinting was associated with longer stance phases in these players when compared with their matched linear sprint segments. Player Z showed smaller or inconsistent GCT differences, suggesting a more constrained mechanical strategy that changes less with task demands. Overall, increased GCT reflects the need for greater mediolateral force control and stability during curved running, supporting the premise that curvilinear demands alter linear sprint mechanics.

6.2. Stride Length (SL)

The largest reductions occurred in C3 and C4, highlighting the cumulative mechanical cost of sustained curve running. Player X had the greatest SL reductions (inside foot: 12%; outside foot: 9%) and may indicate a deliberate trade-off, sacrificing SL to maintain control and speed through the curve. Player Y and Z had smaller relative reductions (C3−L3: ≤10%; approximately ≤ 5% in most segments), again most likely reflecting limited adaptability rather than superior efficiency. These findings align with the expectation that curved running constrains horizontal displacement per step due to centripetal force requirements.

6.3. Push-Off Acceleration

Push-off acceleration had variable percent differences, but the dominant trend was reduction during curvilinear sprinting, particularly in later segments. Player B and Player Z exhibited large negative differences that may infer a reduced ability to generate propulsive force under curvilinear constraints. Player X had smaller reductions or near-zero differences in early curve segments, suggesting better transfer of linear propulsive mechanics into curved sprinting. This supports the interpretation that higher-level runners are better able to reorganize force application without large performance penalties.

6.4. Impact Acceleration

Impact acceleration had the greatest variability across players and segments. Some segments increased impact acceleration during curvilinear sprinting, while others decreased, and may indicate individual landing and stiffness strategies. Player X had moderate positive percent differences ($\geq$15%), consistent with higher foot stiffness and force transmission. Player Z frequently exhibited negative or inconsistent changes, suggesting altered or less stable foot–ground interactions on the curve. This reinforces the notion that impact metrics are particularly sensitive to how runners manage curved trajectories and how they absorb loading at ground contact.

6.5. Inside- vs. Outside-Foot Effects

While both feet had meaningful deviations from linear mechanics, outside-foot values often displayed larger percent differences, especially for GCT and push-off acceleration. This supports the biomechanical expectation that the outside leg bears greater load and force-redirection demands during curvilinear running. However, the magnitude of this effect is player-specific, highlighting individual strategies for managing curve running.

7. Translating IMU Data into Applied Training Decisions

To illustrate how the IMU framework may inform practice, Player Z showed relatively longer GCT, shorter SL, and lower push-off acceleration than Player X and B, with a marked inside–outside push-off acceleration asymmetry during C2. These patterns may suggest that practitioners should first examine whether general acceleration capacity and SL development are limiting factors, while also considering curve-specific drills that target the approach into first base and reacceleration toward second base. For example, a potential training emphasis could include short-resisted curvilinear acceleration drills. Dasso et al. [9] linked hip abductor/adductor strength and inside and outside leg hip abductor symmetry with curvilinear sprint performance; therefore, single-leg hip exercises could be considered, in addition to hamstring [21] and calf [22,23] muscle exercises, which are also important for linear and curvilinear tasks. This example is intended to illustrate how IMU-derived segmental data may guide individualized training hypotheses, rather than to prescribe a definitive intervention or infer a direct causal mechanism.

8. Conclusions

IMU-derived spatiotemporal variables appear to provide a useful diagnostic framework for examining both linear and curvilinear base running mechanics. The perspective analysis was conducted on three baseball players and is intended solely to demonstrate the interpretive framework rather than establish normative performance benchmarks. Segmenting the home-to-second-base sprint allows practitioners to observe how curvilinear demands may alter foot-specific mechanics relative to linear sprint patterns, while the inclusion of asymmetry and linear-curvilinear difference metrics offers additional insight into how base runners reorganize movement under curve-running demands. The present case examples suggest that inside- and outside-foot mechanics can assume distinct and segment-dependent roles during base running, but these examples are intended to illustrate an interpretive framework rather than establish normative patterns or direct causal training effects. From an applied perspective, the IMU approach may help practitioners better understand the individual mechanical characteristics associated with acceleration, curve negotiation, and reacceleration in baseball settings.

9. Practical Application

IMU foot pod technology enables practitioners to identify the mechanical reasons underlying changes in speed, particularly the spatiotemporal constraints responsible for deceleration during base running. By examining sprint segment changes in GCT, SL, push-off and impact acceleration, sport scientists can determine differences between inside and outside feet and identify whether speed loss is primarily associated with excessive braking, insufficient propulsion, longer GCT, or ineffective redistribution of mechanical roles between feet. The inclusion of percent asymmetry and percent difference metrics allows sport scientists to identify technical inefficiencies and compensatory strategies that contribute to speed loss by comparing linear and curvilinear sprint performance. In application, strength and conditioning coaches can use these diagnostics to target curvilinear foundational drills and strength–power interventions based on the specific segments, subject-specific motor preferences, and narrow the gap between high deviations from linear sprint mechanics and changes in asymmetry.

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Abbreviations

The following abbreviations are used in this manuscript:

GCT	Ground Contact Time
SL	Stride Length
IMU	Inertial Measurement Unit

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