BIOMECHANICAL PERFORMANCE ANALYSIS IN ATHLETICS AT THE COLLEGIATE LEVEL

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The purpose of this study was to serve as the platform in presenting biomechanical performance analysis in Athletics at the collegiate level. An inter-collegiate comparison was done to draw upon kinematic data and the role it plays on performance variability. The male 100-meter finalists (n=16) from the 2017 and 2018 Division I Outdoor Track & Field Championships (collegiate experience 3.38 ± 0.60 years) were analysed. Finalists were assigned to one of two groups, *Top 3* (n=6) and *Rest-of-Field* (n=10) based on their placement at these championships. Highlighted was the mean velocity difference (0.30 m/s) and large effect size (0.88) between the two groups from 30-60m. The variable magnitudes reflected differences in technique and an application of sprint mechanics. Therefore, it is appropriate to further investigate the determinant characteristics of college performances.

KEYWORDS: college, determinant, mechanics, sprint.

INTRODUCTION: Contested since its inauguration in 1921 in Division I collegiate athletics (NCAA, 2018), the 100-m has been one of the most anticipated events to witness of the outdoor season. Over the last decade, researchers have collected and published kinematic findings from the Olympic and World Championships in Athletics on the world's elite known sprinters. These reports have served as objective tools for the Athletics community to help classify the trends seen in kinematic parameters among elite sprinters, and how best to understand what influence these trends have on competition outcomes based on the unique traits of individual sprinters (Bissas, 2018). These deductions have given prevued information to members of the athletic world on what and how to consider determinant characteristics that affect performance. As college level performance results prove to border the marks of elites in the rounds of championship caliber meets, it is fitting to gain knowledge on the sprinting technique of this class of athletes and the influence of that technique on the associated characteristics of performance determinants in their chosen event. Thus, a biomechanical performance analysis facilitates coaches and training staff in identifying, but also addressing, indicators of poor technique and mechanical application. By describing the 100-m in component phases—start, acceleration, maximum velocity, deceleration (Morin, 2011)—this study aims to compare the variability in determinant characteristics and their implications on performance through an acquisition of kinematic data on collegiate sprint finalists.

METHODS: The performance of sixteen male collegiate sprinters (collegiate experience 3.38± 0.6 years) from the 100-m finals in the 2017 and 2018 NCAA Men's Division I Outdoor Track & Field Championships held in Eugene, Oregon at Historic Hayward Field were analysed. Combined, finalists were assigned to one of two groups, the first being *Top 3* (n=6) and the second being the *Rest-of-Field* (n=10). Data collection was obtained from footage provided by the Oregon track office and uploaded into a video analyser. A Sony HDRCX455 camera recorded both races from sections B and C of the west grandstands, perpendicular to the 100m straightaway. Dartfish 7.0 was selected as the motion video analysis software program to acquire kinematic data that included official race time, 100-m positions, time per position, velocity, stride count, stride frequency, and stride length. For descriptive statistics, the mean ($\bar{X}$), standard deviation (σ), and effect size (*Cohen's d*) were calculated for each kinematic variable. Effect size was characterised as 0.2, 0.5, 0.8 for small, medium, and large (Cohen, 1988).

To describe performance, variables were defined as: a) official race time (ORT [*s*]); b) time per position (TP [*s*]); c) 100-m positions (0-10, 0-30, 30-60, 60-90, 90-100, 0-100); d) velocity [*m/s*]); e) stride count (SC [*#*]); f) stride length (SL [*m*]); and g) stride frequency (SF [*Hz*]). Component phases were distinguishable as acceleration (0-30), maximal velocity (30-60), maintenance (60-90), deceleration (90-100), and the full race (0-100). As a preliminary study, it is understood that the sample size was small and statistical analysis was limited. Therefore, effect size was evaluated.

Video-based analysis systems for sprint events have been evaluated. In particular, measurements in Dartfish for performance monitoring have shown to possess a limit of precision and correlation of ± 0.01 and r = 0.99, respectively (Haugen, 2015). Thus, measurements for this study were recorded and calculated accordingly with these monitoring points accounted for.

RESULTS: In this preliminary biomechanical performance analysis, a comparison of the mean velocity between the Top 3 and Rest-of-Field groups was completed. Figure 1 illustrates the variability in the mean velocities at specific phases of the race. Overall, the mean difference for the full race was 0.13 m/s, the Top 3 being 9.78 ± 0.23 m/s and the Rest-of-Field reaching 9.65 ± 0.20 m/s. The effect size was of medium level at 0.62. A closer look at the phases revealed a small effect size from 0-30 (0.44), large effect from 30-60 (0.88), large effect from 60-90 (0.85), then ending with a medium effect from 90-100 (0.73). To go along with its effect size, the highest mean velocity was also set in the 30-60 position for both groups, 11.76 ± 0.30 m/s and 11.46 ± 0.36 m/s, respectively. A substantial result to notate was the mean velocity difference of 0.30m/s, 3-folds above any other race position between the two groups. These statistics suggest that the running activity occurring in the middle portion of the race was central to performance times.

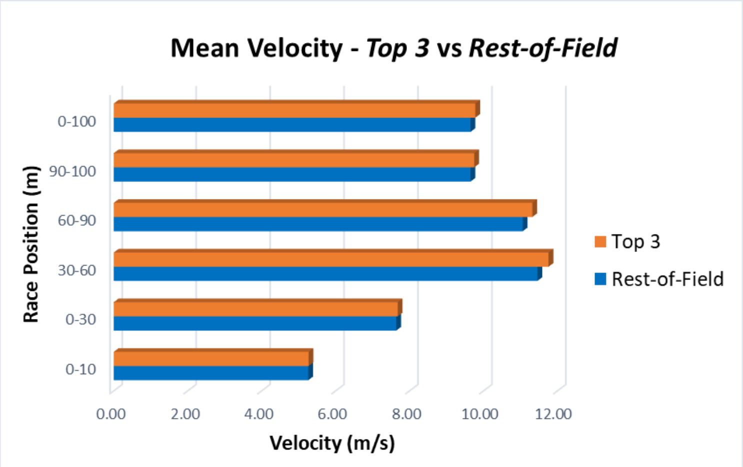

Figure 1. Mean Velocity of *Top 3* vs. *Rest-of-Field*.

In an analysis of the kinematic variables stride count, length, and frequency, Table 1 shows the activity rates of these variables for both groups. For the full race, the mean stride count for the Top 3 was 47.33 ± 1.37 and 46.40 ± 1.58 for the Rest-of-Field, coupled with a mean difference of 0.93 and a medium effect size of 0.62. The Top 3 from 0-100 had a mean stride length of 2.11 ± 0.06m and a mean stride frequency of 4.63 ± 0.23 Hz. In contrast, the Rest-of-Field set a mean stride length of 2.16 ± 0.07m with a mean stride frequency of 4.48 ± 0.18 Hz from 0-100m.

When reviewing where the fastest velocity was produced during the race, it was found that the Rest-of-Field had a shorter stride length than the Top 3 in all race positions except from the 30-60 position (2.23 ± 0.14m, Rest-of-Field vs 2.31 ± 0.00m, Top 3). The reverse was seen in stride frequency in which the Top 3 had a faster stride cadence in each race position except from the 30-60 position (5.10 ± 0.13 Hz, Top 3 vs 5.14 ± 0.42 Hz, Rest-of-Field). The mean differences and their associated effect sizes were 0.08m and 0.68 (medium) for stride length, and -0.04 Hz and -0.12 (small) for stride frequency.

Table 1: Comparative Kinematic Data of *Top 3* vs. *Rest-of-Field*.

		Acceleration	Maximal Velocity	Maintenance	Deceleration	Full Race
	$[\bar{X}] \pm [\sigma]$	0-30	30-60	60-90	90-100	0-100
Velocity [m/s]	Top 3	7.68 ± 0.13	11.76 ± 0.30	11.32 ± 0.13	9.75 ± 0.64	9.78 ± 0.23
	Rest-of-Field	7.64 ± 0.06	11.46 ± 0.36	11.06 ± 0.37	9.17 ± 0.87	9.65 ± 0.20
	Mean Difference	0.04	0.30	0.26	0.58	0.13
	Cohen d.	0.44	0.88	0.85	0.73	0.62
SC [#]	Top 3	16.83 ± 0.75	13.00 ± 0.00	13.00 ± 0.63	4.50 ± 0.55	47.33 ± 1.37
	Rest-of-Field	16.50 ± 0.53	13.50 ± 0.85	12.30 ± 1.42	4.10 ± 0.32	46.40 ± 1.58
	Mean Difference	0.33	-0.50	0.70	0.40	0.93
	Cohen d.	0.53	-0.73	0.58	0.96	0.62
SL [*m*]	Top 3	1.79 ± 0.08	2.31 ± 0.00	2.31 ± 0.11	2.25 ± 0.27	2.11 ± 0.06
	Rest-of-Field	1.82 ± 0.06	2.23 ± 0.14	2.47 ± 0.34	2.45 ± 0.16	2.16 ± 0.07
	Mean Difference	-0.03	0.08	-0.16	-0.20	-0.04
	Cohen d.	-0.52	0.68	-0.57	-0.97	-0.62
SF [*Hz*]	Top 3	4.31 ± 0.20	5.10 ± 0.13	4.90 ± 0.22	4.39 ± 0.61	4.63 ± 0.23
	Rest-of-Field	4.20 ± 0.14	5.14 ± 0.42	4.53 ± 0.53	3.74 ± 0.21	4.48 ± 0.18
	Mean Difference	0.11	-0.04	0.37	0.65	0.15
	Cohen d.	0.64	-0.12	0.84	1.60	0.79

DISCUSSION: The purpose of this study was to compare the variability in the characteristics associated with performance determinants in the 100-m sprint at the college level. The kinematic analyses of elite performances in previous research have been used to evaluate the quality of acceleration, force, and velocity productions during sprinting (Samozino, 2015). Reports have provided coaches with an opportunity to draw upon these research findings to bring about progress in training conducive to performance improvement. Thus, an inter-collegiate biomechanical performance analysis may educate coaches, athletes, and training staff on what kinematic measurements within determinant characteristics mark a separation in performance between the Top 3 as opposed to the Rest-of-Field.

The 100-m sprint requires an ability to react to the starting gun, accelerate, transition into maximal velocity, maintain that velocity, and finish the race with a focus on technique as fatigue continues to ensue. The execution of these phases is predicated on having proper technique during race positions. When technique is compromised, the mechanics of sprinting are affected thus decreasing the athlete's ability to apply determinants effectively during sprint performance. In the acceleration phase of the 100-m, the mean velocity difference was 0.04m/s, with a small effect size of 0.44. A medium effect size of 0.73 during the deceleration phase was similar to the 0.62 effect size seen in the overall race. Considerable differences between the two groups were found during the maximal velocity and maintenance phases in which the mean velocity differences were 0.30m/s (30-60) and 0.26m/s (60-90). These results suggest that the athletes in the Top 3 group had the ability to be more efficient in their technique in order to produce and maintain velocity during those race phases.

To further analyse determinants of velocity during the 100-m sprint, the kinematic values for stride length and stride frequency were noted as well. Hay's deterministic model describes the relationship between stride length, stride frequency, and velocity (Hay, 1994). In this study from 30-60, the mean stride length between the two groups was the only positive value difference at 0.08m (2.31 ± 0.00m, Top 3; 2.23 ± 0.14m, Rest-of-Field) among all race positions. In contrast, the stride frequency difference was the only negative value of all race positions at -0.04 Hz (5.10 ± 0.13 Hz, Top 3; 5.14 ± 0.42, Hz Rest-of-Field). The results suggest that stride length is a more important determinant of higher velocity for the Top 3 between 30-60m. From 60-90, the mean stride frequency between the two groups was 0.37 Hz with a large effect size of 0.84. In looking at 90-100, the mean stride frequency and effect size was even greater, 0.65 Hz and 1.60, respectively. These results suggest that stride frequency is a more important determinant towards the second half of the race, covering 60-100m. It can be inferred that the frequency of strides in contact with the ground, where force is applied in the proper direction due to efficient technique, increases the athlete's opportunity to sustain their step length while losing velocity at a slower rate over time (Bissas, 2018). It is then essential to develop technique where stride frequency and stride length support the mechanical requirements of each race phase.

CONCLUSION: A biomechanical performance analysis using kinematic data at the collegiate level allowed for a better understanding of differences between the top finishers and the rest of the field. In this study, Top 3 finishers over the Rest-of-Field demonstrated substantially different velocity, stride length, and stride frequency profiles across the race phases. A focus on understanding the variability and how to effect one determinant characteristic without compromising another is critical in the adaptations and developments that occur during a college career. This study illustrates the practical value in performance analysis in order to execute applications of sprint mechanics. Therefore, it is fitting to further investigate collegiate Athletics from a biomechanical perspective in an effort to make improvements towards performance.

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