Sprint acceleration mechanical profiling for the NFL draft

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Headline

The NFL Scouting Combine is a weeklong event where a group of high-performing graduating collegiate American football (AF) athletes are invited to a central location to undergo a series of physical, psychological and technical evaluations. Running speed and acceleration abilities are critical capacities for performance in AF, and therefore the 40-yard (36.6 m) dash represents one of the most important physical tests. It may be that performance in this particular test, and the underlying mechanical determinants, are related to achieving the goal of being drafted into the NFL.

Aim. This study aimed to firstly describe the sprint acceleration mechanical profile of athletes participating in the NFL Scouting Combine, and to secondly ascertain which biomechanical variables are associated with selection in the NFL draft.

Methods

Design. A retrospective observational research design was employed, where data was obtained from freely available online resources, and therefore, no ethical approval was required.

Protocol

Data extraction. Sprint (9.1, 18.3 and 36.6 m splits) and anthropometric (height and body mass) for the period 2013-2017 were extracted from website nflcombineresults.com, and collated with NFL draft results that were obtained from the website nfldraft.com. Draft l were categorised into three discrete groups, as 1 = early draft (first 100 players drafted within that respective year), 2 = late draft (> first 100 players drafted), or 3 = undrafted. Players were classified by position, as Linemen (offensive line and defensive line), Big Skill (tight ends, quarterbacks and linebackers) and Skill (running backs, wide receivers and defensive backs).

Sprint profiling. Sprint times were analysed using customised software (R Studio, v. 3.4.3.), according to the methods of Samozino and colleagues (1). Two input variables required for the analysis were unavailable (ambient temperature and air pressure), and were therefore assumed to be constant (20°C and 1000 mmHg, respectively) throughout all analyses. A summary of output variables can be found in Table 1.

Statistical Analysis

Differences between draft stages (i.e. early, late or undrafted) were determined using a one-way ANOVA for each position group (Linemen, Big Skill or Skill), for each outcome measure. Between-group differences were determined using the Tukey's HSD test, and then converted to an effect size (ES; ±90% CI) using the between-subject SD. The likelihood of the observed effect was interpreted using a magnitude-based approach (2). All analyses were performed in R Studio (v. 3.4.3.).

Results

Figure 1 illustrates the F-V relationship for each position group. The sprint values for each of the eight position groups are presented in Table 2. Of the 1254 sprint files analysed, 390 were classified as undrafted [3], whilst 400 and 464 were classed as early [1] and late [2] draft picks, respectively. Differences in sprint variants between early, late and undrafted players are presented in Figure 2.

Discussion

This study aimed to present the underlying mechanical determinants of sprint acceleration exhibited by AF athletes attempt to achieve selection in the NFL draft. The primary finding of this study was that players who were selected early in the draft (i.e. first 100 picks) exhibited well-developed mechanical properties when compared to players who were undrafted, and to a lesser extent players who were drafted late (i.e. after first 100 picks). However, these associations do not necessarily infer cause-and-effect, and therefore it is difficult to ascertain whether players are drafted early because they performed better in the 40-yard dash, or whether highly skilled players are also mechanically efficient sprinters.

American football is typically a short distance and duration sport, involving infrequent but intense bursts of activity (3). As such, the ability to accelerate rapidly is important for many aspects of competition, such as wide receivers achieving separation from defenders, or a running back attempting to accelerate through a closing gap in the defense. It is therefore unsurprising that sprint acceleration mechanical properties are able to differentiate players who are drafted early from those drafted late or left undrafted in these skill-based positions. An interesting finding of the present study was these variables were similarly able to separate players in positions that are less dependent on running during matches, such as offensive and defensive linemen. These positions are rarely required to sprint maximally throughout training and competition (3), though well-developed acceleration capacities still seem important for being drafted into the NFL.

Being a collision-based sport, stature and body size are considered as major contributors to performance in AF (4). The findings of the present study are in support of this notion, where absolute variables separated the three draft statuses more clearly than their relative counterparts. Importantly, absolute variables were better able to differentiate players who were drafted early than those who were drafted late, which suggests that body mass is an important consideration for NFL teams when making their draft selections.

Across all three position groups, absolute horizontal power (P_max) was not only able to delineate drafted and undrafted players, but was also useful for discriminating early draft picks from late draft picks. During sprint acceleration, horizontal power represents a product of both force and velocity capabilities. Athletes may achieve peak horizontal power via efficient

Table 1. Definition and practical interpretation of biomechanical variables of interest during power-force-velocity sprint profiling.

Profiling Variable	Definition	Practical Interpretation
F0 (N/kg)	Theoretical maximal horizontal force production, extrapolated from the linear sprint F-V relationship.	Maximal force output (per unit body mass) in the horizontal direction. Initial "push" of the athlete into the ground during sprint acceleration.
F0 (N)	Same as above, but in absolute terms.	
P_*max* (W/kg)	Maximal mechanical power output in the horizontal direction.	Maximal power-output capability of the athlete in the horizontal direction (per unit body mass) during sprint acceleration.
P_*max* (W)	Same as above, but in absolute terms.	
V0 (m/s)	Theoretical maximal running velocity, extrapolated from the linear sprint F-V relationship.	Sprint-running maximal velocity capability of the athlete, should mechanical resistances be null. Ability to produce horizontal force at high velocities.
Momentum (kg.m/s)	Product of body mass and V0.	Sprint-running maximal momentum capability of the athlete, where higher values are theoretically favourable in a collision-based sport.
RF_*max* (%)	Maximal ratio of force (RF), computed as ratio of step-averaged horizontal component of the ground reaction force to the corresponding resultant force (for sprint times >0.3 sec).	Theoretical maximal effectiveness of force application. Proportion of total force production that is directed in the forward direction of motion at start of sprint.
DRF (% per m/s)	Rate of decrease in RF with increasing speed during sprint acceleration, computed as the slope of the linear RF-V relationship.	Describes the athlete's capability to limit the inevitable decrease in mechanical effectiveness with increasing speed.

F = force; V = velocity; P = power; N = Newton; kg = kilogram; W = Watt; m = metre.

Table 2. Descriptive statistics of biomechanical variables of interest during power-force-velocity sprint profiling for all positions.

	Linemen (n = 421)		Big Skill (n = 258)			Skill (n = 575)		
	Offensive Line (n = 205)	Defensive Line (n = 216)	Tight End (n = 59)	Linebacker (n = 134)	Quarterback (n = 65)	Running Back (n = 139)	Wide Receiver (n = 205)	Defensive Back (n = 231)
Height (m)	1.95 ± 0.04	1.92 ± 0.04	1.94 ± 0.04	1.87 ± 0.04	1.91 ± 0.04	1.79 ± 0.05	1.85 ± 0.03	1.82 ± 0.06
Body mass (kg)	142.2 ± 5	129.6 ± 11.8	114.5 ± 4.3	109.4 ± 5.4	101.9 ± 4.6	97.9 ± 7.3	92 ± 4.3	90.2 ± 7.2
F0 (N/kg)	8.5 ± 0.7	9.4 ± 0.8	9.7 ± 0.7	10.2 ± 0.7	9.6 ± 0.8	10.4 ± 0.9	10.5 ± 0.9	10.7 ± 0.7
F0 (N)	1201 ± 80	1211 ± 102	1115 ± 81	1116 ± 95	976 ± 90	1013 ± 100	964 ± 102	963 ± 88
V0 (m/s)	8.66 ± 0.32	9.18 ± 0.51	9.74 ± 0.33	9.65 ± 0.44	9.54 ± 0.42	10.06 ± 0.43	10.34 ± 0.39	10.23 ± 0.38
Momentum (m.kg/s)	1231 ± 53	1186 ± 73	1115 ± 49	1055 ± 62	972 ± 57	983 ± 66	951 ± 50	922 ± 76
P_*max* (W/kg)	18.3 ± 2	21.6 ± 2.6	23.7 ± 1.8	24.6 ± 1.8	22.8 ± 2.2	26.1 ± 2.3	27.1 ± 2.5	27.3 ± 1.9
P_*max* (W)	2600 ± 202	2776 ± 222	2714 ± 208	2691 ± 231	2328 ± 235	2542 ± 229	2488 ± 254	2461 ± 215
RF_*max* (%)	46.5% ± 1.4%	49.5% ± 2.2%	51.3% ± 1.4%	52% ± 1.8%	50.6% ± 1.9%	53% ± 1.7%	53.8% ± 2%	54% ± 1.3%
DRF (%)	-9.1% ± 0.7%	-9.4% ± 0.8%	-9.1% ± 0.7%	-9.6% ± 0.8%	-9.2% ± 0.8%	-9.3% ± 0.9%	-9.1% ± 0.9%	-9.4% ± 0.8%

F = force; V = velocity; P = power; N = Newton; kg = kilogram; W = Watt; m = metre.

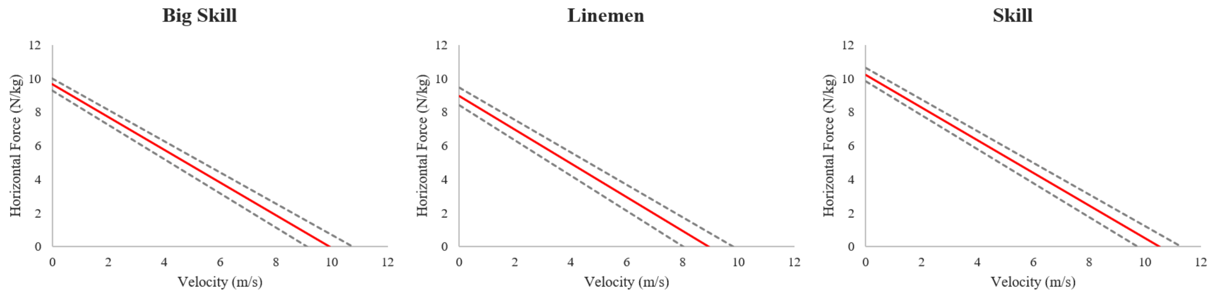

Fig. 1. Visual representation of the F-V relationship of players participating in the NFL combine. Red line represents mean value for each position, grey dotted line denotes 1 SD. N/kg = Newtons per kilogram; m/s = metres per second.

horizontal application of force during the initial pushes of the athlete into the ground at the start of the sprint (i.e. RFmax and F0), or the ability to maintain a horizontal orientation of force as velocity increases (V0). As such, P_*max* may be incorporative of athletes exhibiting both force- and velocity-dominant sprinting capabilities.

The incorporation of body mass into this metric increased the magnitude of differences between draft statuses, which may suggest NFL teams are interested in bigger players with superior sprinting abilities, however this remains speculative.

When comparing the values presented in the present study with those of previous research, the values for relative F0 and P_*max* presented in the current study are substantially higher than those reported in rugby league and rugby union players (5), and somewhat comparable to elite-level 100-m sprinters (6,7). It may be plausible that some positions exhibit similar mechanical characteristics to high-level sprinters, though these elevated force and power variants are likely falsely inflated by the unique semi-automated timing system employed by combine officials. Briefly, this technique required the timing of the sprint to be initiated manually, which is later adjusted, presumably to account for the lag that occurs due to human reaction time. Unfortunately, this limitation is unavoidable, and comparisons with previous research must be made cautiously.

Practical Applications

- Mechanical profiling of the 40-yard dash provides practitioners with a more holistic overview of the sprint acceleration profile of the athlete.
- Players participating in the NFL scouting combine can use this technique to identify areas of improvement during preparation for this event.

Limitations

- The present study did not attempt to quantify ambient conditions that may affect sprint mechanics (wind resistance, air pressure etc.), though these factors are considered to have only a small impact on the results.
- The semi-automated timing system utilised in the NFL scouting combine may have altered results, making comparisons with published literature difficult.

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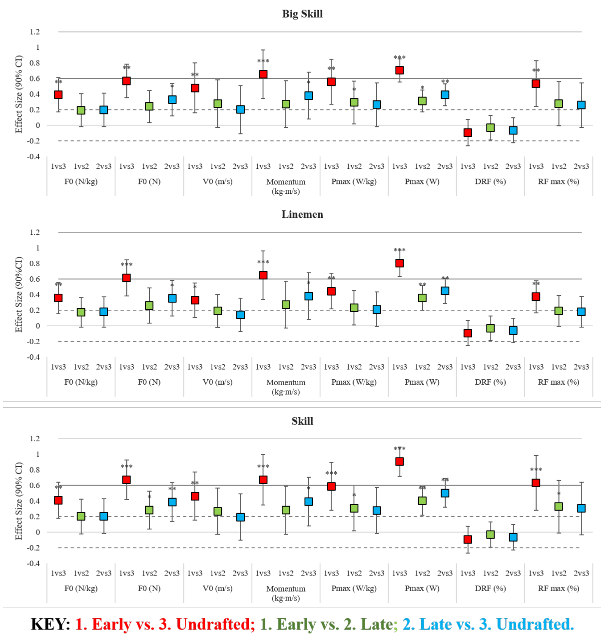

Fig. 2. Difference between draft statuses for each of the selected F-V profile variables. F = force; V = velocity; P = power, N= Newton; m = metre; s = second; W = Watt; * = likely; ** = very likely; *** = almost certainly.