Science of NFL Football: Kinematics - Position, Velocity & Acceleration

NBC's Lester Holt and former NFL running back Deuce McAllister explore kinematics on the playing field. NSF-funded scientists Tony Schmitz from the University of Florida and John Ziegert of Clemson University explain how the kinematic concepts of position, velocity and acceleration can be used to define how a running back moves. "Science of NFL Football" is a 10-part video series funded by the National Science Foundation and produced in partnership with the National Football League.

Keywords

Transcript

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LESTER HOLT, reporting:

From big and bulldozing, to small and speedy, NFL running backs come in many shapes and sizes. But to succeed at football, all running backs must excel at kinematics, the branch of classical mechanics that defines how objects move.

Dr. TONY SCHMITZ (University of Florida): Because kinematics describes motion, it describes everything an NFL running back does basically, which is his motion up the field as he tries to score.

HOLT: Kinematics uses three concepts to define motion: position, velocity and acceleration. Position defines location within a space, such as the surface of a football field.

Dr. JOHN ZIEGERT (Clemson University): The position relative to the goal line changes the set of options that the running back has in terms of the direction he chooses to run.

HOLT: In this play, let's define the running back's position where he takes the hand-off. After executing the play, however, his new position is his opponent's end zone.

Dr. DEUCE McALLISTER (Former NFL Running Back): A long, long time ago, almost right at ten years ago, my 40-yard dash was 4.26.

HOLT: To help illustrate the concepts of kinematics, Deuce McAllister, all-time leading rusher for the
New Orleans Saints, performed the 40-yard dash in front of a high-speed Phantom camera.

McALLISTER: You want to stay low as possible while running the 40, particularly the first 10-yards. So it’s literally like you’re being shot out of a cannon.

HOLT: Using McAllister's personal best in the 40, 4.26 seconds, it's easy to calculate his speed. Divide the distance by the time to get his average speed – 9.39 yards-per-second, or 28.17 feet-per-second. To define the velocity, simply add a direction: 28.17 feet-per-second, north.

SCHMITZ: When we talk about speed, we’re talking about the magnitude of velocity. And then its direction is dictated by where the running back goes.

HOLT: On the field, great speed is used to elude tacklers.

MARSHALL FAULK (Former NFL Running Back): When you have speed and you have very good speed, that five yard play for most backs becomes a 50-yard play.

HOLT: Also helpful is the ability to cut, or suddenly change directions.

LOUSAKA POLITE (Miami Dolphins Running Back): That helps you make moves against the defender, that helps you get free from being tackled.

HOLT: Beyond position and velocity, the third kinematic concept is acceleration, which describes how fast speed is changing.

McALLISTER: You never know when you may need to hit that button, you know, per se, to accelerate at maximum speed.

HOLT: To understand acceleration, consider again McAllister's 40-yard dash. While his average speed is 28.17 feet-per-second, his instantaneous speed varies. He starts with zero speed and then increases his speed, or accelerates, until he reaches a top speed -- let's say, hypothetically, 31.5 feet-per-second. If we know how long it takes McAllister to hit his top speed, let's assume 1.2 seconds, then it's possible to calculate his acceleration as the change in speed divided by the time.

SCHMITZ: Acceleration is the change in velocity per unit time, which if we compare it to velocity was the change in distance per unit time.

HOLT: In this case, 31.5 feet-per-second, divided by 1.2 seconds, means that McAllister's acceleration was 26.25 feet-per-second squared.

SCHMITZ: We want to reach our top velocity as quickly as possible. Someone with low acceleration might take five yards to reach top velocity, while someone with great acceleration might be able to reach top velocity in half that distance.

HOLT: On the playing field, acceleration, or the ability to reach top speed quickly, may be a running back’s most potent weapon.

FAULK: If you can accelerate, you’re going to get to top speed even if your top speed isn’t as fast as the guy that’s faster than you, you’re going to beat him to his top speed, therefore you’re going to be more successful than he is.

HOLT: Without kinematics and its concepts of position, velocity and acceleration, NFL running backs would be easy prey, and football, itself, wouldn't be nearly as fun to watch.