ASSESSMENT OF DECELERATION ABILITY AND RELATIONSHIP TO APPROACH SPEED AND ECCENTRIC STRENGTH

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The purpose of this study was to develop a method for assessing an athlete's deceleration ability and investigate its relationship with acceleration distance, % maximum speed and eccentric strength. A Laveg LDM 300C was used to collect peak speed and distance of 9 male athletes in a 30m maximal sprint and acceleration-deceleration efforts within set distances of 5, 10, 15 and 20m. The 'deceleration gradient' derived from 10m and 5m peak speeds and stopping distances was found to exhibit a low association with eccentric strength of the quadriceps ($R^2 = 0.284$) and hamstrings ($R^2 = 0.219$). Equations were generated linking % maximum speed attained with acceleration distance ($R^2 = 0.961$) and stopping distance ($R^2 = 0.851$) which could help to set realistic conditions for acceleration-deceleration drills and to revise speed zones within match analysis applications.

KEY WORDS: acceleration, stopping distance

NTRODUCTION: Changing direction at high speed is a skill inherent in many sports. The ability to change direction quickly and in a controlled manner can differentiate between levels of ability within a sport (Sheppard & Young, 2006) helping athletes to create space and to make or avoid tackles. Directional changes also carry a high risk of injury to the knee and ankle joints (Cochrane et al., 2007), making agility a particularly interesting area for biomechanical research. However, studies have tended to focus on the contact phase of the turning foot as this is often the leg that gets injured. Considering that the ACL is most at risk in the first 17-50ms of contact and 5-30 degrees of knee flexion (Krosshaug et al., 2007; Koga et al., 2010), then it is highly unlikely that any meaningful interventions can be administered to offset this occurrence. If we are to help reduce the risk of injury then we need to re-examine the constituent parts of the change in direction movement and find opportunities where interventions could make a difference.

A change of direction task has four phases; an initial acceleration-in, deceleration, turn and acceleration-out. In tasks that require a 90 to 180 degree turn, successful execution requires the athletes to come to an instantaneous stop in the direction of approach, i.e. zero velocity. Logically, if we can reduce the ground reaction forces imparted through the turning leg this will reduce knee joint loads, potentially reduce injury and shorten turn times. Surprisingly limited studies have given any real insight into the mechanisms of the deceleration into a turn. Graham-Smith et al. (2009), Jones et al. (2016) and Dos'Santos et al. (2017) quantified load distribution in the penultimate and final (turn) contacts and found that faster performances in a 180 degree turn were associated with greater braking forces and knee joint moments in the penultimate contact and lower contact times in the turn. The knee joint is better aligned with the force vectors in the penultimate contact, thereby placing it in a stronger position to decelerate the body. Given the current emphasis on producing faster athletes, there is a distinct lack of concern over how athletes decelerate, and more importantly what interventions could be done to enhance performance and reduce injury risk. To build on the work of the previous studies it is important to put the changing of direction movement into context. The maximum speed that an athlete can attain prior to changing direction dictates how much braking impulse needs to be imparted. In game scenarios there is no specified 'approach' distance, so in order to understand the loading demands we first need to evaluate athletes' ability to accelerate and decelerate within set distances. This will quantify the typical speeds athletes can attain over short distances (relative to their maximum sprint speed), and the stopping distances for that given speed.

The aims of this study were: to develop a method to quantify deceleration qualities of athletes (with respect to acceleration distance and % maximum speed attained), and to examine if deceleration ability is related to eccentric strength of the knee extensors and flexors.

METHODS:
Nine male subjects took part in the study, mean age 32.3 ± 4.2 years and body mass 69.2 ± 4.9 kg. Subjects provided written informed consent prior to participation, they were injury free and were employed as strength and conditioning coaches in professional football clubs. A standardised warm up was undertaken prior to testing speed and strength.

A Laveg LDM 300C laser speed device was used to assess maximum sprint speed over 30m and maximum speed and stopping distance during rapid acceleration-decelerations trials within prescribed distances of 5-10-15 and 20m relative to a 'zero' point (denoted by a cross on the ground, figure 1). The Laveg sampled at 100Hz data and was processed with a 51 point moving average to produce instantaneous speed vs. distance profiles (figure 2). The peak speed attained and the distance at which this occurred relative to the 'zero' point were extracted. Three trials were performed at each distance and the average of these values recorded for each subject. There was no restriction on deceleration distance for the 30m sprint, and this provided a reference as to what % of maximum speed could be attained over each of the acceleration-deceleration trials. Subjects were instructed to complete the task as fast as possible with maximum acceleration and to finish with both feet on the cross. If they over-stepped the cross, they were asked to repeat the trial. The distance at peak speed denoted the onset of deceleration and the 'stopping distance'. Acceleration distance was calculated as the difference between the starting distance and the stopping distance. Acceleration-deceleration trials were conducted in a randomised order.

A 'deceleration gradient' was calculated for each subject using the mean peak speed and stopping distance data for the 5m and 10m trials. To establish an overall indication of the typical stopping distance requirements, polynomial curves were fitted to all subjects % maximum speed data with their corresponding acceleration and stopping distances.

Concentric and eccentric strength of the knee extensor and flexor muscle groups were assessed within one week of the sprint tests using a Biodex System 4 isokinetic dynamometer. Gravity corrected peak torques were measured over five maximal repetitions at an angular velocity of 60 deg/s using the con/con and ecc/ecc testing modes. The sum of the left and right leg peak torque values for eccentric knee extensors and eccentric knee flexors were divided by body mass and analysed for their association to the deceleration gradient. Relationships were tested using the Pearson Product Correlation Coefficient and the coefficient of determination (R^2).
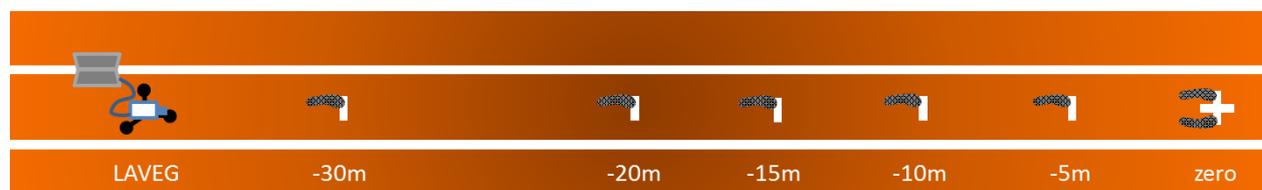
Figure 1: Experimental layout.

RESULTS & DISCUSSION: A typical speed-distance profile can be seen in figure 2 and the average peak speed and stopping distances are presented in Table 1. The mean deceleration gradient was -0.74 ±0.11 m/s per metre with a range of -0.55 to -0.90.

The mean sum of the left and right eccentric knee extensors peak torque was 581 Nm ± 78 (8.3 x BM ± 0.9) and eccentric knee flexors 340 N.m ± 44 (4.9 x BM ± 0.4). Eccentric strength of the knee extensors and flexors were found to exhibit moderate levels of association with the deceleration gradient with values of $R^2 = 0.281$ and 0.219 respectively. This suggests that other factors, such as technique (step length and frequency patterns, knee, trunk and leg placement angles, Graham-Smith and Pearson, 2005), load distribution strategy (Graham-Smith et al,

2009; Dos'Santos et al (2017) and passive loading mechanisms at impact may play important contributory roles in deceleration.
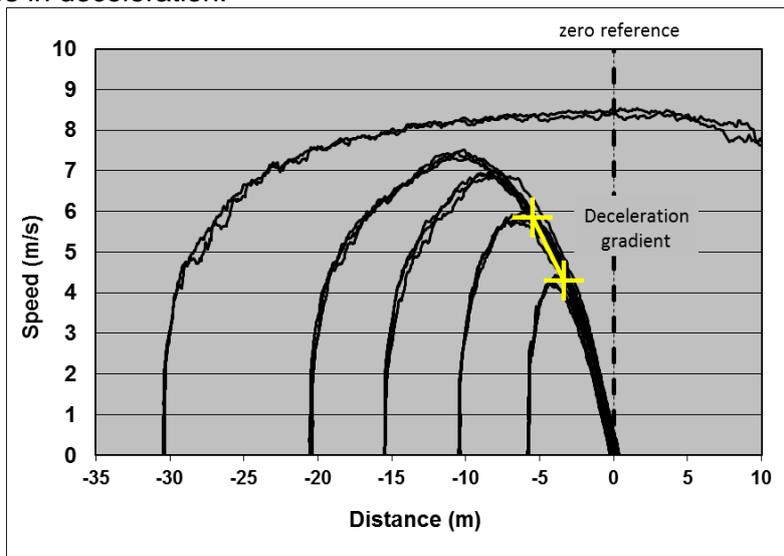

Figure 2: Typical speed-distance graph for maximal sprint and acceleration – deceleration trials (denoting the 'deceleration gradient').

Table 1
Maximum speed and stopping distances (n=9)

Trial	Speed (m/s)		% Max Speed		Stopping Distance	
	Mean	SD	Mean	SD	Mean	SD
30m Max Sprint	8.1	0.6				
5m	4.4	0.1	54.2	3.9	-2.93	0.12
10m	5.8	0.2	72.2	3.2	-4.94	0.39
15m	6.7	0.2	83.0	3.2	-6.61	0.40
20m	7.2	0.3	89.1	2.5	-7.93	0.62

$$y = -0.3063x^2 + 7.804x + 39.672$$
$$R^2 = 0.961$$
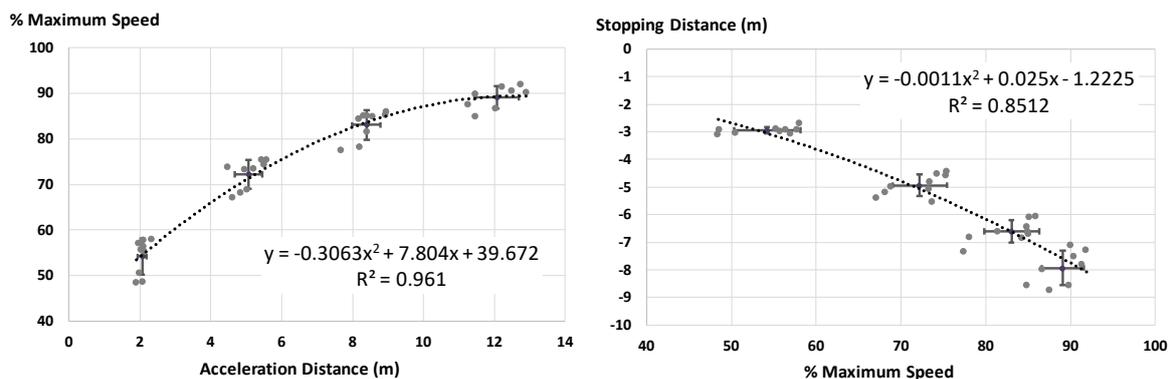
$$y = -0.0011x^2 + 0.025x - 1.2225$$
$$R^2 = 0.8512$$

Figure 3: Acceleration and deceleration distance relationships with % maximum speed attained

The main issue when evaluating maximum deceleration qualities is that athletes' must first be running at their highest possible speed and this speed cannot be standardised. The method developed in this study has evaluated the athletes' deceleration ability in relation to their self-determined limit to accelerate within the prescribed distance. The stopping distance is logically dependent on the acceleration distance and the peak speed an athlete can attain prior to them initiating a braking strategy in order to stop (or perform a turn if necessary), and therefore reflects an athlete's perceptual awareness of their strength, proprioception and technical attributes to successfully achieve the test constraints. The % of maximum speed attained was used to standardise approach speed across athletes. Polynomial curve fitting generated

equations linking acceleration distance to % maximum speed ($R^2 = 0.961$) and % maximum speed to stopping distance ($R^2 = 0.851$). Interestingly, the data reveals that 54% of an athlete's maximum speed can typically be attained within 2m of initiating an acceleration movement and this would require approximately 3 m to decelerate within a total movement distance of 5m. Within team sports, it is not uncommon for players to accelerate 10 m. In this scenario a player could attain 87% of maximum speed and it would require around 7.4 m to decelerate effectively, within a total movement distance of 17.4 m.

CONCLUSION:
The information provided in this paper is pertinent to S&C coaches and physiotherapists who work in team sports or with athletes who are required to make rapid acceleration-deceleration movements or changes of direction. The study has provided a novel new method to quantify a deceleration gradient which can be used to profile this quality over time. The equations presented in figure 3 can also be used to help develop their understanding and application of appropriate stopping distances based on the distances of acceleration drills and the typical speed a player is likely to attain. By setting appropriate stopping distances coaches and biomechanists can work with players to determine the most effective and safest braking strategies to condition players to withstand the loading demands imposed on players in these high risk movements. The methods and findings are also pertinent to performance analysts and physiologists who use arbitrary speed zones within their match analysis software to revise and redefine intensity of movement based on the distance the player sprints. It is recommended that research conducted on change of direction tasks seek to provide context on the deceleration demands and the deceleration qualities of their subjects, as these are fundamental precursors to the braking strategies and techniques adopted in those tasks.

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