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SHORT-TERM BIOMECHANICAL ADAPTATION IN A MAXIMUM VELOCITY FIELD SPORT SPRINTING PROTOCOL: PILOT INVESTIGATION

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The aim of this study was to investigate short-term biomechanical adaptation of maximum velocity running in response to two sprint protocols; anticipated, where the athlete knew and unanticipated, where he didn't know the required sprint distance prior to entering a test zone. An automatic motion analysis system was used to track sagittal plane marker locations during anticipated and unanticipated maximum velocity sprints performed by an experienced male university football player (age: 23 years, body mass: 85 kg, stature: 1.86 m). Significant increases for the anticipated condition (p <0.05) were found in the step length (0.03 m) and flight distance (0.02 m) over the first 20 m. These short-term technique adaptations indicated that sprint-training protocols for open skill sports may facilitate greater specificity in training by integrating unanticipated movement tasks.

KEY WORDS: step characteristics, technique, training specificity.

INTRODUCTION: In a large variety of field sports that require the utmost mobility, such as agility and maximal velocity sprinting, the environment is frequently and often unpredictably changing. As a consequence an athlete may be unable to effectively pre-plan the movement pattern, rendering the required movement pattern an open skill (Schmidt & Wrisburg, 2008). The ability of the athlete to adapt rapidly and successfully to unanticipated changes in constraints may be considered desirable, especially for performance in an open skill (Schmidt & Wrisburg, 2008). In training, a coach can manipulate the task constraints to help the performer search for functional and individualised coordination solutions and to stimulate the range of conditions encountered during competition. By becoming familiar with different permutations of a task constraint, a participant may learn to adapt rapidly to changes in those constraints during competition (Sanders, Li & Hamill, 2009). Short-term biomechanical adaptation is distinguished from a generic definition of biomechanical adaptation in that it may be considered to be the reorganisation of a stable movement pattern to cope with a sudden unanticipated change in task or environmental constraints.

Field sports such as football, field hockey and rugby are, by nature, classed as open skills and require the athlete to interpret the environment to adapt their movements, often in a short amount of time (Sheppard, Young, Doyle, Sheppard & Newton, 2006; Schmidt & Wrisburg, 2008). Within many field sports, straight line sprint running is an integral component of successful performance with the maximum running velocity phase an essential element of these sports (Meir, Colla & Milligan, 2001). The maximum 20 m sprint test, where the athlete begins the run protocol while already at their maximum velocity, has been used routinely by sport scientists and coaches as a measure of a performer's top speed, and as a training tool to elicit physiological adaptations. However, because the movements were capable of being pre-planned due to there being no reaction to a stimulus (Schmidt and Wrisburg, 2008), such protocols have been criticised for application to open skills (Sheppard et al., 2006).

When examining single subject and group responses to constraining factors, Sanders *et al.* (2009) advocated a focus on the individual because previous research has argued that the group response does not accurately reflect the individual's performance (Dufek, Bates, Stergiou & James, 1995). The existence of individuals performance variation has underlined why the statistical technique of pooling individual data (e.g. means, standard deviations) may have restricted value in contemporary biomechanics research (Davids, Glazier, Araújo & Bartlett, 2003). The coefficient of variation (CV %) has been used in previous sprinting research to assess the variability of performance and kinematic measures (e.g. Bradshaw,

Maulder & Keogh, 2007) and is often used as an index of intra- and inter-individual movement variability (e.g. Hausdorff, Zemany, Peng & Goldberger, 1999).
Utilising a single subject design, the modification of the maximal 20 m sprint test to include open skill elements might allow for the effect of short-term biomechanical adaptation on performance outcome to be investigated and may further help to inform coaching practice. Consequently, the aim of this pilot investigation is to examine the short-term biomechanical adaptation in maximum velocity sprint performance in response to changes in a field sport-specific task constraint.

METHODS: Participant & Protocol: One male collegiate level football player (age 23 years, body mass 85 kg and stature 1.86 m) was recruited for the study. The study was approved by the University's' Local Research Ethics Committee and the participant was injury free and provided written informed consent prior to the onset of the data collection.
The participant started from an individually prescribed location (distance greater than 25 m) from the start of a 20 m performance area. The participant was instructed to be travelling at their maximum running velocity when they entered the start of the 20 m performance area. At the onset of reaching the 20 m collection area a set of visual stimulating smartspeed™ light gates were illuminated at three different unanticipated sprint target distances (20 m, 30 m or 40 m from the start of the performance area). Following the stimulation of the respective light gate, the participant was instructed to maintain their maximum running velocity until passing the target. While the unanticipated target distances were randomised, the participant was informed of the target distance (20 m) prior to the onset of the anticipated condition. A total of 9 trials were performed for each condition (N = 36 trials in total).
Data Collection & Processing: Four cartesian optoelectronic dynamic anthropometer scanners (CODA, 6.30B-CX1 motion analysis , Charnwood Dynamics, UK) sampling at 200 Hz were horizontally aligned 3 m perpendicular to the plane of motion and at 2.5 m, 7.5 m, 12.5 m and 17.5 m locations from the onset of the 20 m performance zone. The scanners were used to track three-dimensional active markers located on the dorsal aspect of the fifth metatarsal head of the left foot and the first metatarsal head of the right foot. The two-dimensional (anterior-posterior: y; vertical: z) coordinate marker data were filtered with a fourth order, low-pass Butterworth filter (cut off frequency: 12Hz).
Data Analysis: Toe-off (initiation of the swing phase) and touchdown (initiation of the stance phase) for each trial were defined during the 20 m capture volume using the previously employed kinematic definition of Bezodis, Thomson, Gittoes & Kerwin (2007). A step was subsequently defined from the instant of toe-off (initial) of one foot to the instant of the following toe-off (final) event for the contralateral foot. The step length (SL) was determined as the y-displacement of the toe marker between the respective toe-off events. The step frequency (SF) was correspondingly defined as the reciprocal of the duration between the initial and final toe-off events, and the step velocity (SV) was determined as the product of the SL and SF. The analysis also included the measurement of the flight distance (FD), flight time, contact distance, contact time and step time. The mean (±s) for each of the step characteristics was determined as the average measure across all steps performed in every trial for the anticipated 20 m (N =75 steps in total), unanticipated 20 m (N = 75 steps in total), unanticipated 30 m (N = 75 steps in total) and unanticipated 40 m (N = 75 steps in total) conditions. The step characteristics for each condition were tested for sphericy and the Greenhouse Geisser correction was used if the assumption was violated for a condition (Field, 2009). After checks for normality and sphericy a repeated measures ANOVA was performed separately on the step characteristics to compare between conditions with a further pairwise comparison using a Bonferroni post hoc test ($p = 0.05$). The coefficient of variation (CV %) for each step characteristic was calculated by dividing the standard deviation by the mean for each sprint condition and multiplied by 100.

RESULTS: The anticipated 20 m condition elicited a greater SV, SL and FD when compared to the unanticipated conditions (Table 1). The anticipated 20 m condition had a significantly greater ($p < 0.05$) SL and FD than the unanticipated 20 m condition. No differences were observed between conditions for SF or any of the determinants of SF. The CV % was lowest (3.01 %) in the anticipated 20 m condition for SV when compared to all the unanticipated conditions (3.42 %), while for SL and FD the anticipated 20 m condition produced the greatest CV % than all the unanticipated conditions.

Table 1. Mean (±s) step characteristics and coefficient of variation (CV %) for the 20 m performance zone for every anticipated and unanticipated condition (N = 75 steps for each condition).

Step Characteristic	Anticipated 20 m (A20)	Unanticipated 20 m (U20)	Unanticipated 30 m (U30)	Unanticipated 40 m (U40)
Step Velocity (m/s)	8.49 ±0.26	8.42 ±0.29	8.43 ±0.29	8.47 ±0.29
CV %	*3.01*	*3.42*	*3.10*	*3.46*
Step Length (m)	2.10 ±0.08	2.07 ±0.06*	2.08 ±0.06	2.08 ±0.06
CV %	*3.68*	*3.04*	*2.95*	*2.89*
Step Frequency (Hz)	4.06 ±0.19	4.07 ±0.20	4.06 ±0.17	4.08 ±0.20
CV %	*4.77*	*4.82*	*4.10*	*4.90*
Flight Distance (m)	2.06 ±0.07	2.04 ±0.06*	2.04 ±0.06	2.04 ±0.06
CV %	*3.60*	*3.14*	*3.02*	*3.00*
Contact Distance (m)	0.04 ±0.01	0.04 ±0.02	0.04 ±0.01	0.04 ±0.02
CV %	*36.12*	*41.32*	*31.93*	*40.99*
Step Time (s)	0.25 ±0.01	0.25 ±0.01	0.25 ±0.01	0.25 ±0.01
CV %	*4.78*	*4.79*	*4.05*	*4.87*
Contact Time (s)	0.12 ±0.01	0.12 ±0.01	0.12 ±0.01	0.12 ±0.01
CV %	*5.17*	*5.97*	*4.72*	*4.66*
Flight Time (s)	0.13 ±0.01	0.13 ±0.01	0.13 ±0.01	0.13 ±0.01
CV %	*7.43*	*7.17*	*6.37*	*7.11*

* Significant difference to the anticipated 20 m condition ($p < 0.05$).

DISCUSSION: Field sports are by nature, classed as open skill and require the athlete to interpret the environment to adapt their movements, often in a short amount of time. The alteration of the closed skill maximal 20 m sprint test to include open skill changes in final maximum running velocity distance could potentially allow for the effect of short-term adaptation on performance outcomes to be investigated. The present pilot investigation subsequently examined the short-term biomechanical adaptations in maximum velocity sprint performance in response to changes in a field sport-specific task constraint.

The unanticipated change in final sprint distance resulted in reduced SV of the performer over the 20 m performance zone when compared to the anticipated condition. The reduction in SV suggested that the open skill response of the performer may have compromised their performance when compared to the traditionally employed closed skill protocol. The reduction in CV % in the anticipated condition for SV suggested that the performer was more consistent in maintaining a greater SV than in each of the unanticipated conditions. Since SV is the product of step frequency and SL (Hunter, Marshall & McNair, 2004), the performer significantly ($p < 0.05$) adapted their SL, while maintaining their SF in the unanticipated 20 m condition. The reduction of SL and maintenance of SF are consistent with previous literature that has investigated the effect of changing constraints of step characteristics (Alcaraz, Palao, Elvira & Linthorne, 2008), all be it in closed skill environments. The modified SL and maintained SF for changed task constraints has also been reported by Letzelter, Sauerwein & Burger (1995), who suggested that their female sprinters were attempting to compensate for the large decline in SL by overemphasising SF. The reduction of SL with the unanticipated conditions, according to Hunter et al.'s (2004) hierarchal model of sprint performance, may be due to the adaptation of either the SD or the FD. The FD was significantly ($p < 0.05$) shorter in the unanticipated 20 m condition and reduced in all other unanticipated conditions when compared the anticipated 20 m condition. For both FD and SL, the step characteristics that significantly changed, the anticipated condition had a greater CV % than each unanticipated condition. The reduction in CV % could be an indication of the compensatory freezing of degrees of freedom as a result of a skilled performer responding to unanticipated changes in task constraint (Davids *et al*., 2003). Consequently it emerged that the performer may have adapted their pre-planned anticipated movement pattern caused by the unanticipated change in sprint distance by reducing the FD of the step. The current single subject study provided an initial indication of potentially important mechanisms of adaptation, which may be investigated further to enhance understanding of short-term biomechanical adaptation in maximum velocity sprinting. The observation that the performer adapted their technique as a result of the change in protocol from a closed skill to an open skill provided further argument (Sheppard *et al.*, 2006) against the use of closed skill protocols for the training of field sport performers. With further investigation, open skill protocols may be developed to allow a performer to become familiar with different permutations of a task constraint and to adapt rapidly to changes in those constraints during competition (Sanders *et al*., 2009).

CONCLUSIONS: The study aimed to gain an initial insight into the short-term biomechanical adaptations made when performing maximum velocity sprints of different anticipated and unanticipated sprint distances. The introduction of unanticipated changes in task constraint and a corresponding short-term, individualised biomechanical adaptation highlighted the potential need for coaches to implement protocols that include open skill elements.

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Hideki Nakatani. Impact patterns in soccer kick motion for elementary school boys. (97)

IMPACT PATTERNS IN SOCCER KICK MOTION FOR ELEMENTARY SCHOOL BOYS

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