ACUTE EFFECTS OF TECHNICAL INSTRUCTIONS ON SPRINT ACCELERATION TECHNIQUE AND PERFORMANCE

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This study investigated the acute effect of verbal technical instructions intended to alter attentional focus during a 10 m sprint. Team sports athletes (n = 15) completed maximal effort sprints under a control condition and two experimental conditions: internal and external focus. Lower-body kinematic and external kinetic data were collected near the 5 m mark. Total sprint time was longer in both experimental conditions than the control condition ($p < 0.05$). Both experimental conditions altered ankle and knee angles at touchdown and led to more vertically oriented ground reaction forces (all $p < 0.05$). Whilst these instructions were detrimental to performance, the results support the importance of technical ability for sprint acceleration. Future studies should seek to identify instructions, potentially used within training programmes, which could be beneficial to performance.

KEY WORDS: attentional focus, kinematics, kinetics, skill acquisition, sprinting, touchdown.

INTRODUCTION: Sprint acceleration is a fundamental ability for many team sports. Acceleration performance has been widely demonstrated to be related to the strength of an athlete but this relationship is typically only moderately strong and the remaining variation in sprint acceleration performance is often unexplained by further measures of physical capacity. Relatively recently, the additional importance of technical ability for acceleration has been established. It has been shown that an ability to direct the ground reaction force (GRF) vector more horizontally, rather than to generate greater GRF *per se*, is a feature of effective sprint acceleration (Kugler & Janshen, 2010; Morin et al., 2011; Rabita et al., 2015). This ability can be quantified by calculating the ratio of force (Morin et al., 2011) whereby the horizontal component of the GRF vector is expressed as a percentage of the total GRF vector magnitude (and typically averaged over an entire ground contact). However, whilst the importance of achieving a high ratio of force for sprint acceleration is becoming increasingly accepted, the strategies with which this can be achieved remain unclear.

From a cross-sectional study of physical education students, it was suggested that one strategy used to generate greater horizontal propulsive force is landing with the stance foot further behind the centre of mass (Kugler & Janshen, 2010). The potential importance of this technical feature is also supported by theoretical simulations which demonstrated that manipulating knee angle at touchdown to move the foot further behind the centre of mass (CM) led to a higher ratio of force for an accelerating international sprinter (Bezodis et al., 2009). It therefore appears possible that experimental manipulations to touchdown kinematics, in particular the stance foot position relative to the CM (often termed touchdown distance), could be used to affect sprint acceleration performance.

To initially investigate this as an acute intervention, a means through which to manipulate touchdown technique is required. One method which has been demonstrated to be effective for acutely affecting technique and performance in numerous movement tasks, including maximal effort vertical and horizontal jumping, is to manipulate a performer's attentional focus through the instructions they are given (Wulf, 2013). The aim of this study was therefore to determine the acute effect of verbal technical instructions intended to alter an athlete's attentional focus on sprint acceleration technique and performance.

METHODS: Following ethical approval, 18 competitively-active male team sport (Gaelic football, rugby union, soccer) athletes (mean ± SD: age = 22 ± 4 years, mass = 78.2 ± 10.5 kg, height = 1.76 ± 0.10 m) provided written informed consent to participate but were naive to the aim of the study. All participants completed a series of maximal effort 10 m sprints in each of three experimental conditions (control, internal focus, external focus).

These conditions were performed sequentially, but their order was counterbalanced across participants. Verbal instructions were provided to the participants just prior to every sprint. In all conditions, participants were instructed to "complete the 10 m sprint as quickly as possible". In the control condition, no further instructions were given. For the internal focus, the instructions continued with "whilst focussing on pulling your leg backwards just before each contact with the ground". For the external focus, the instructions continued with "whilst focussing on clawing backwards at the ground with your shoe in every step you take". These instructions were based on the suggestions of Wulf (2013) that they should be similar in content and amount of information; both were intended to direct attention to actions at touchdown based on the rationale for this study. To qualitatively assess whether appropriate attentional foci were adopted, all participants completed a written manipulation check after each condition (Peh et al., 2011). No augmented feedback was provided; participants were not aware of their sprint times and were not given any feedback regarding their movements.

The sprints were completed in training shoes on an indoor rubber track in a laboratory. All sprints commenced from a self-initiated standing start behind a set of timing lights with a second set placed 10 m away to determine 10 m sprint time. The exact location of both sets of timing lights was adjusted slightly between participants and conditions to ensure that complete ground reaction forces (GRFs) were recorded using a force platform (Kistler, 9287BA; 960 Hz) between 4.5 and 5.5 m into each sprint. Thirty-eight reflective markers (25 mm in diameter) were attached to each participant to define and track seven segments (pelvis, thighs, shanks, feet) using an 11 camera Vicon MX-3 system at 240 Hz. Marker trajectories and GRF data were collected synchronously using Vicon Nexus (v. 1.8.5).

The raw marker trajectories were labelled and exported for analysis in Visual3D (v. 5.01). Marker trajectories were digitally filtered at 20 Hz and segmental kinematics were reconstructed using an evenly-weighted inverse kinematics approach which prohibited joint translations. Hip, knee and ankle joint angles and angular velocities were calculated based on the orientation and angular velocity of the distal segment in the coordinate system of the proximal segment. Touchdown and toe-off were identified from the raw vertical GRF data (10 N threshold) and ground contact time was determined. Flexion/extension angles and angular velocities, foot touchdown velocity and touchdown distance were identified at touchdown (where touchdown occurred between frames of kinematic data, linear interpolation was used). Foot touchdown velocity was the horizontal velocity of the stance foot CM at touchdown and touchdown distance was the horizontal distance between the pelvis CM and the stance foot CM at touchdown. Peak GRFs and horizontal impulses (trapzium rule) were determined and these discrete data were normalised by dividing by body weight and by mass, respectively. The ratio of horizontal to total force production as an average of all of the instantaneous values over the entire contact phase was calculated using the procedures of Morin et al. (2011). Toe-off from the preceding step was determined when the vertical position of the 5^{th} metatarsal-phalangeal (MTP) marker first exceeded 10 mm and the flight time prior to contact on the force plate was determined. Step length for the step on to the force platform was calculated using global antero-posterior coordinates of the 5^{th} MTP marker between adjacent toe-offs. To assess the effects of the experimental conditions, a repeated measures ANOVA was run on each of the above dependent variables. Where a significant ($p < 0.05$) main effect was observed, Tukey's least significant difference post hoc tests were run to identify any significant ($p < 0.05$) pairwise differences.

RESULTS: Following a qualitative analysis of the manipulation check data, three participants were removed due to reporting attentional foci which conflicted with one or more of the intended experimental conditions (i.e. $n = 15$ for all quantitative analyses). There was a significant main effect of condition on 10 m sprint time; post hoc tests revealed that sprint times were significantly longer (i.e. worse performance) in the internal (1.992 ± 0.120 s) and external (1.992 ± 0.112 s) focus conditions compared to the control (1.936 ± 0.095 s). There was no significant difference in 10 m sprint time between the internal and external focus conditions. For the kinetic data, there was a significant main effect of condition on peak vertical GRF and the ratio of force (Table 1). Peak vertical GRF was significantly greater in both of the experimental conditions than in the control condition, and the ratio of force was lower (i.e. a more vertically directed GRF vector) in both of the experimental conditions than in the control condition. For the kinematic data, there was no effect of condition on touchdown distance or foot touchdown velocity (Table 1). However, in both experimental conditions, the ankle was significantly more plantar flexed at touchdown and the knee was significantly more extended at touchdown than in the control condition. Hip extension angular velocity was significantly lower in the internal focus condition than in the control condition.

Table 1
Kinetic, temporal and kinematic variables from all conditions (mean ± SD)

		Control	Internal focus	External focus
Peak resultant GRF (BW)		2.46 ± 0.26	2.56 ± 0.23	2.54 ± 0.21
Peak propulsive GRF (BW)		0.75 ± 0.08	0.75 ± 0.07	0.76 ± 0.07
Peak braking GRF (BW)		-0.53 ± 0.23	-0.52 ± 0.25	-0.53 ± 0.28
Peak vertical GRF (BW)	*	2.43 ± 0.26 ^{I,E}	2.60 ± 0.30 ^{C}	2.52 ± 0.22 ^{C}
Braking impulse (m/s)		-0.04 ± 0.02	-0.04 ± 0.02	-0.04 ± 0.02
Propulsive impulse (m/s)		0.51 ± 0.06	0.49 ± 0.07	0.49 ± 0.05
Net propulsive impulse (m/s)		0.46 ± 0.05	0.44 ± 0.07	0.45 ± 0.06
Ratio of force (%)	*	25.2 ± 2.5 ^{I,E}	23.5 ± 3.1 ^{C}	23.9 ± 2.2 ^{C}
Flight time (s)		0.076 ± 0.013	0.084 ± 0.017	0.081 ± 0.016
Step length (m)		1.37 ± 0.10	1.42 ± 0.10	1.41 ± 0.10
Ground contact time (s)		0.150 ± 0.018	0.144 ± 0.025	0.148 ± 0.023
Foot touchdown velocity (m/s)		1.31 ± 0.61	1.09 ± 0.74	1.14 ± 0.67
Touchdown distance (m)		0.12 ± 0.04	0.12 ± 0.04	0.13 ± 0.05
Ankle angle (°)	*	1.6 ± 3.2 ^{I,E}	-1.6 ± 4.4 ^{C}	-0.9 ± 4.4 ^{C}
Knee ankle (°)	*	45.4 ± 5.4 ^{I,E}	43.3 ± 6.9 ^{C}	43.8 ± 6.0 ^{C}
Hip angle (°)		40.9 ± 8.5	40.0 ± 11.5	41.2 ± 10.8
Ankle angular velocity (°/s)		50 ± 102	59 ± 101	87 ± 113
Knee angular velocity (°/s)		-99 ± 139	-62 ±129	-36 ± 123
Hip angular velocity (°/s)	*	-502 ± 105 ^{I}	-453 ± 107 ^{C}	-468 ± 121

* denotes significant main effect. Superscript I, C and E denote significantly different from control, internal focus and external focus conditions, respectively. Joint angles and angular velocities are the values at the instant of touchdown. Angles are expressed relative to a neutral standing trial with positive values denoting flexion/dorsiflexion. A positive angular velocity represents flexion/dorsiflexion.

DISCUSSION: This study found that two different types of instructions intended to acutely manipulate touchdown kinematics during sprint acceleration led to significantly slower 10 m sprint performance than when these team sport athletes were just instructed to sprint “as quickly as possible”. These instructions, which altered the participants’ attentional focus, also led to changes in technique in both experimental conditions compared to the control condition. Participants responded to both sets of instructions by increasing plantar flexion at touchdown but this was compensated for, in terms of the unchanged touchdown distance, by an increase in knee extension at touchdown. During the stance phase immediately following this touchdown, the peak vertical GRF magnitude was significantly higher and the average ratio of force during stance was significantly lower (more vertical) in both of the experimental conditions compared to the control condition. Based on recent research demonstrating the importance of directing the GRF vector more horizontally during sprint acceleration (Kugler & Janshen, 2010; Morin et al., 2011; Rabita et al., 2015), these GRF changes may explain the reduction in performance observed during both experimental conditions in comparison to the control condition. It is possible that the altered stance limb kinematics at touchdown are related to the change in ratio of force in the current study. The current findings therefore identify some potential technical determinants of ratio of force worthy of further exploration. These findings also provide experimental evidence from team sport athletes to further support the importance of ratio of force for sprint acceleration performance.

Enhanced performance with an external attentional focus relative to a control or internal focus has been reported in numerous movement tasks and sport skills (see Wulf et al., 2013), including horizontal and vertical jumping where GRF impulse production determines performance. These studies have primarily investigated performers who are at Newell's (1985) coordination, or more likely control, stage of learning (Peh et al., 2011). When expert performers at the skill stage of learning were studied, Wulf (2008) identified that both an external and internal attentional focus negatively affected automaticity of movement compared to a control condition. Given that the participants in the current study had all been involved in their respective team sports since adolescence, it is likely that their sprint acceleration movement patterns were highly automated and they could thus be considered to be at Newell's (1985) skill stage of learning. The use of attentional focus based interventions to positively affect performance in such a well-established movement pattern as that used to maximally accelerate may therefore be limited. One possible exception to this may be if external focus instructions can be designed which lead to environmentally-focussed attention rather than skill-focussed attention. In many of the tasks where an external focus has previously been demonstrated to be beneficial for performance (see Wulf et al., 2013) the external focus was environmental (e.g. trajectory of a projectile). It has been demonstrated that if skilled performers direct attention towards the skill being performed, irrespective of whether this is internally or externally focussed, performance is reduced relative to focussing on the environment (Castaneda & Gray, 2007). If a suitably simple and relevant external environmental focus can be identified for sprint acceleration, it is possible that an external focus could lead to a different outcome from that observed in the current study.

CONCLUSION: Instructions which manipulated attentional focus during a maximal effort 10 m sprint acceleration task led to an acute reduction in performance irrespective of whether this focus was internal or external. The negative effect of these instructions on performance may have been due to the highly automated nature of sprint acceleration movement in these participants. However, given that these instructions did induce acute changes in technique, this suggests that attentional focus manipulations based on verbal instruction can be effective in manipulating technique. It is possible that if instructions which induce an external environmental focus can be designed, these may be beneficial for performance. It would also be of interest to determine the effects of a longer-term training intervention with technical instructions on sprint acceleration technique and performance.

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