INFLUENCE OF TRICEPS SURAE ELECTROMECHANICAL DELAY ON MOVEMENT RESPONSES IN THE SPRINT START EVENT

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This study examined the delay in sprint start performance related to electromechanical delay (EMD) in the triceps surae muscle and aimed to determine whether sprinters may gain an advantage in sprint start response time (SSRT). SSRT's of nineteen sprinters were measured using an International Association of Athletics Federations approved SSRT detection system. EMD times were also obtained from the triceps surae muscle during a simple heel-lift experiment. Using Brosnan et al. (2016) response time limits, the results demonstrated that EMD produced a significant moderate correlation with SSRT (r = 0.572, P = 0.01). Initial results suggest EMD influences SSRT. However greater specificity in the EMD measurement to the sprint start action is required to determine the true effects of EMD on SSRT.

KEY WORDS: response delays, track and field, response time, performance testing

INTRODUCTION: In the sprint start, response delays follow a well-established sequence of events. This delay sequence can be subdivided into signal processing time (SPT) and electromechanical delay (EMD). SPT includes the delays between the start signal stimulus onset and muscle activation (Komi, Ishikawa, & Jukka, 2009). EMD can be further subdivided into two distinct time periods; force development time (FDT); the delay between muscle activation and force production and elastic charge time (ECT); the delay between force production and movement. The sprint start response time (SSRT) is defined as the time elapsed between the presentation of the auditory start signal and the instant the athlete exerts a predetermined force against the starting blocks (Mero, Komi, & Gregor, 1992). Since athletes' muscles will be tensed in the set position, some of the EMD or its components may be reduced. Despite this, EMD has been proposed as a contributing factor of SSRT which may add ≈10 ms to the SSRT (Komi et al., 2009). To date, there is a lack of experimental evidence to demonstrate the degree to which EMD may influence SSRT.
At present, there is also a level of ambiguity surrounding the International Association of Athletics Federations (IAAF) 100 ms rule. The IAAF rule states that a false start occurs when a sprinter registers a SSRT <100 ms after the gun, and this results in an automatic disqualification (International Association of Athletics Federations, 2015). Komi et al. (2009) questioned the validity of this rule and highlighted that SSRT's lower than the 100 ms IAAF criteria are possible. Research is needed to map out the kinetic sequence of events that occur during the sprint start in order to determine the minimum legal response time. Based on the assertions of Komi et al. (2009) that mechanical delays appear to be a component of SSRT, an investigation into the influence these components have on SSRT (i.e. EMD, FDT, ECT) and the variances in the size of these times across sprinters, is warranted.
The primary aim of this exploratory experiment was to examine the correlations between SSRT and EMD, FDT, and ECT in the triceps surae muscle using previously established techniques for measuring EMD. This research aimed to examine the extent to which response delays, particularly EMD, may influence SSRT. This study is one element of a broader research programme aiming to map the response time sequence of events in the sprint start and improve understanding of how SSRT detection can be improved in competition. It is hoped that this research could contribute to the ongoing debate on false start detection in competition (International Association of Athletics Federations, 2015).

METHODS: Following approval by the local University Research Ethics Committee, nineteen national and international level sprinters (16 ♂, 3 ♀, age: 23 ± 3 years, 177 ± 9.2 cm, 73.4 ±

9.3 kg, athletics training experience: 7.4 ± 3.0 years, IAAF event scoring points: 953 ± 116 points) participated in this study. All athletes were proficient with the starting technique procedure and had starting block experience.

Data collection and analysis: For the SSRT assessment, testing was conducted at an international standard indoor 60 m sprint track (Mondo). IAAF approved starting blocks were used (Stadium, Gimtrac, Centurion, South Africa). SSRT's were obtained using Starting Module (TimeTronics, Olen, Belgium), a wireless system which was mounted on the rear of the block rail sensors. Participants set block spacing and obliquity to their individual preferences prior to trials. Sprint trials were conducted in accordance with IAAF starting procedures (International Association of Athletics Federations, 2015) and performed by an IAAF Certified Starter. Participants completed three competitive 15 m sprints from starting blocks in competition with another athlete and 2-3 minutes of recovery given between sprints to mitigate any effects of fatigue. Each SSRT was examined and trials that satisfied the IAAF 100 ms rule were used to calculate a mean SSRT for each participant. Additionally, the mean SSRT was calculated for each participant for legal trials in accordance with Brosnan, Hayes, and Harrison (2016) revised response time thresholds of 115 ms (men) and 119 ms (women).

The EMD in the triceps surae muscle of the participants' preferred front starting block leg was then determined using a simple heel-lift activity described by Winter and Brookes (1990). Participants sat on a plastic chair with the knee of the chosen leg flexed to 90°. The ball of the foot was positioned on the force platform of the heel-lift experimental rig, with the heel resting on a foot switch integrated into the experimental rig. Electromyography (EMG) electrodes were placed on the surface of the soleus and over the lateral epicondyle of the femur. Individualised rigid plastic "cut-outs" were attached to the participant's heel using double sided sticky tape. These allowed a precise identification of the instant of the first movement. An auditory electronic signal was utilised as instruction for the participant to plantar flex the foot as quickly as possible. Ten trials were performed for each participant. Rest periods between trials were 30 to 60 seconds. EMG, force plate, electronic signal and foot switch data was collected using a PowerLab 4/20 system and LabChart 8 software (AD Instruments, Sydney, Australia) connected to the experimental rig and a standard laptop. Data was sampled at 1000 Hz. The point where the M-wave started was accepted as the onset of EMG activity and the instant of foot plantar flexion force was force onset. The heel movement was identified by the foot-switch. FDT was calculated as the time interval from the onset of EMG activity to force production. ECT was calculated as the time interval between force registration and detection of movement by the heel switch. EMD was calculated as the time interval from the onset of EMG activity to the detection of movement in the heel switch.

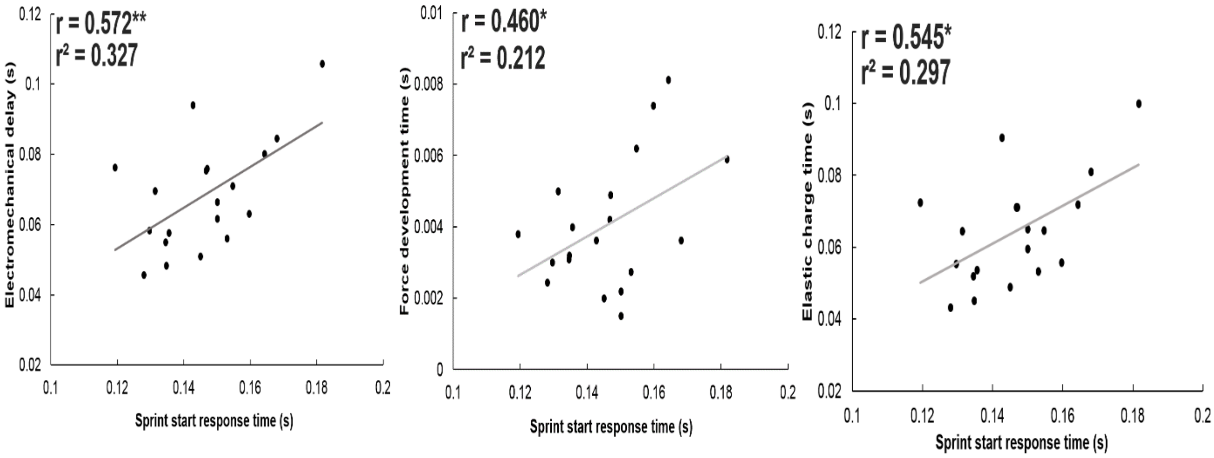
Statistical analysis: All statistical calculations were performed using SPSS V24.0 (IBM Co., NY, USA). A bivariate correlation analysis was conducted that investigated the association between SSRT and heel-lift experimental variables using Brosnan et al. (2016) SSRT limits. Means and standard deviations were calculated for all variables. Bootstrapping was used to evaluate bias, standard error, and 95% confidence intervals. Statistical significance was set at $P < 0.05$ for all analyses and correlation coefficients (r), coefficients of determination (r^2) were calculated. Correlations were calculated using Pearson's r.

RESULTS AND DISCUSSION: The number of false starts increased substantially when the Brosnan et al. (2016) SSRT limits were implemented, highlighting the inadequacy of the current IAAF rule. As IAAF equipment and SSRT limits were used during the testing procedure, only three false starts were detected by the IAAF system/rule during testing. Using Brosnan et al. (2016) SSRT limits, twelve false starts were identified. This revised response time threshold was calculated based on World and European Championship SSRT data from 1990 to 2014 and provides a more rigorous method of ensuring false starts are not included in the analysis. Subsequently, for the correlation analysis, revised SSRT (Table 1) in accordance with Brosnan et al. (2016) limits were used.

Table 1. Time intervals (mean ± SD) of the heel-lift experiment variables and sprint start response time

Experiment	Variable	Time intervals (ms)
Heel-lift	Electromechanical delay (EMD)	68.3 ± 15.8
Heel-lift	Elastic charge time (ECT)	64.2 ± 15.0
Heel-lift	Force development time (FDT)	4.1 ± 1.8
Sprint start	Sprint Start Response time (SSRT)	146 ± 15.5

Table 1 presents the mean ± SD of the measured variables from the heel-lift experiment and the sprint start experiment. Komi et al. (2009) proposed that mechanical delays (i.e. EMD, ECT and FDT) are an influencing factor on SSRT. The results of the analysis agree with the Komi et al. (2009) estimation, with EMD producing a significant moderate correlation (r = 0.572, P < 0.05) with SSRT. Moderate significant correlations were also observed between SSRT and ECT (r = 0.545, P < 0.05), and FDT (r = 0.460, P < 0.05), see Figure 1.



**P < 0.01; *P < 0.05

Figure 1. Correlation scatterplots detailing the relationships between sprint start response time (SSRT) versus electromechanical delay (EMD), force development time (FDT) and elastic charge time (ECT).

These data suggest that EMD contributes to a sprinter's response time and that some athletes may gain a performance advantage due to decreased EMD. However, there is low movement specificity in the heel-lift experiment compared to a block start and as a result, the degree to which EMD influences SSRT in the blocks remains unknown at present. In the "set" position of the sprint start, the sprinter's muscles are pre-tensed and pre-activated. This lack of pretension during the heel-lift experiment may effectively reduce the inherent series elastic slack, which is a central component of EMD value in a muscle (Cavanagh & Komi, 1979; Vittasolo &

Komi, 1981). Therefore, if EMD were to be examined during a block start the mechanical delay could be expected to be smaller than measured during the current study.
Unless SSRT and EMD are simultaneously measured in starting blocks during a sprint start the true effect of mechanical delays on sprint start performance cannot be confirmed. Future research should examine EMD with instrumented sprint start blocks using force transducers for quantifying force registration and a foot switch or high-speed kinematic analysis to detect movement onset. The attachment of high-frequency (> 1000 Hz) wireless EMG sensors to the athlete's limbs could enable the quantification of time delays between muscle activation, force development, and movement onset (i.e. SSRT). In this proposed research, EMD should be quantified as the change in the electrical activity and force after the "set" position has been assumed (i.e. muscle will already be pre-tensed in "set" and electrical activity and force evident). This research will be technically challenging, however investigating the influence of EMD of SSRT is an important component of mapping out the kinetic sequence of events in the sprint start.

CONCLUSION: This study provided an indication that EMD times are moderately correlated with performance during the sprint start and highlighted the need for pretension in the set position. Future research examining the influence of response delays should incorporate a sprint-specific measure of EMD so its association with SSRT performance can be thoroughly examined.

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