# SPATIO-TEMPORAL PARAMETERS AND INSTANTANEOUS VELOCITY OF SPRINT RUNNING USING A WEARABLE INERTIAL MEASUREMENT UNIT

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**KEY WORDS:** sprint running, biomechanics, inertial sensors

**INTRODUCTION:** Wearable inertial measurement units (IMU) provide movement-related data without any space limitation or cumbersome setup. They can be proficiently used to perform an in-field biomechanical analysis of sprint running providing information useful for performance optimisation and injury prevention. Mechanical key quantities characterizing sprint running performance are instantaneous velocity and displacement of the athlete (Cavagna et al., 1971). However, the process of determining velocity and position by numerical integration of acceleration is jeopardized by the noise characterizing the signal of micro-machined accelerometers (Thong et al., 2002). The aim of this study was to compensate these errors by reducing the integration interval, taking advantage of *a priori* known laws of motion, and by cyclically determining the initial conditions of the integration process, in order to yield reliable spatio-temporal parameters during sprint running.

**METHODS:** A male subject (26 yrs, 73 kg, 1.73 m) performed 7 in-lab sprints, starting from a standing position. Due to limited lab volume (12*9*4 m) only the first 3 steps were considered. 3D linear acceleration and orientation of a wearable IMU positioned on the upper back trunk (MTx, Xsens; m=30g) were collected and the following parameters were estimated over each cycle: 1) stance time (*ST*); 2) centre of mass progression displacement (*d*); 3) variation of vertical and progression velocity ($\Delta v_v$, $\Delta v_p$). Reference data were obtained as follows: ST from a contact-sensitive mat (stance 1) and two force platforms (Bertec) (stance 2-3); Δv and *d* from stereophotogrammetry (Vicon MX, Plug-in-Gait protocol). The average of the absolute percentage difference ($e_{abs\%}$=|(reference-inertial)*100/reference|), referred to as error ($e_{\%}$), was calculated for each parameter.

**RESULTS:** Reference and sensor estimates and percentage error are reported in Table 1.

**Table 1. Parameter and percentage error values (mean ± standard deviation) for three stance**

| | stance 1 | | | stance 2 | | | stance 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | reference | inertial | $e_{\%}$ | reference | inertial | $e_{\%}$ | reference | inertial | $e_{\%}$ |
| ST [s] | 0.23±0.01 | 0.21±0.01 | 7±4 | 0.18±0.01 | 0.17±0.01 | 6±2 | 0.17±0.01 | 0.19±0.01 | 8±3 |
| d [m] | 1.31±0.06 | 1.22±0.07 | 7±2 | 1.37±0.18 | 1.30±0.18 | 6±2 | 0.89±0.28 | 0.89±0.27 | 3±2 |
| $\Delta v_p$ [$ms^{-1}$] | 0.95±0.06 | 0.99±0.11 | 7±4 | 0.67±0.02 | 0.78±0.04 | 17±7 | 0.42±0.11 | 0.34±0.07 | 21±11 |
| $\Delta v_v$ [$ms^{-1}$] | 1.41±0.11 | 1.27±0.11 | 11±7 | 1.68±0.27 | 1.38±0.16 | 17±8 | 1.65±0.37 | 1.30±0.25 | 27±6 |

**DISCUSSION AND CONCLUSION:** The obtained Δv percentage errors are consistent with respect to the literature (Vetter et al., 2008). Even though these errors still increase at each stance phase, the methodology is sensitive to the variations of velocity determined by the reference measurement system. As regards ST and d, no similar previous study has been reported. However since the methodology relies on the identification of foot contact timings for reducing the integration interval, small errors in the determination of these parameters, are encouraging. Future developments concern in-field sprint running experimental sessions.

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