Sprint acceleration mechanical outputs: direct comparison between GPEXE Pro2 and 1080 Sprint devices

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Force-Velocity | **Reliability** | **Sprint performance** | **Acceleration** | **Team sport**

Headline

Sprint force-velocity profiling is a simple and practical way to accurately assess the macroscopic propulsion capacities underlying players' sprint acceleration performance (1–3). Since this approach can be based on position- or speed-time data, many systems can be used depending on the context (e.g. radar, laser, timing gates or Global Positioning System (GPS) units) (4). It is thus important to study inter-device differences to inform about the magnitude of intra- and inter-device reliability. The increasing accuracy and popularity of GPS in team sport justifies the investigation of sprint force-velocity main outcomes derived from speed-time data obtained with this technology (5). Our aim was to assess the differences between a specific model of GPS and a linear encoder training and testing device, and compare their inter-trial reliability.

Methods

Participants

Seven recreational athletes (mean ± SD age of 24 ± 0.6 yrs; body mass 74.3 ± 7.9 kg; height 1.83 ± 0.08 m; 100-m personal best time 11.37 ± 0.22 s) participated to this study. They were fit and without known pathology, all familiar with this type of testing method and maximal acceleration sprinting.

Study design

During this testing procedure, every subject was equipped with a GPS unit (GPEXE Pro2, Exelio SRL, Italy, firmware version 0.13) and attached at the waist to the 1080 Sprint device (1080 Motion AB, Stockholm, Sweden) following the manufacturer's instructions. Data were measured simultaneously by each device and sampled at 18.18 Hz (GPS) or 333 Hz (linear encoder). The testing procedure took place in an open field stadium to prevent any potential GPS interference, and the following GPS measurement details were obtained: mean ± SD number of satellites of 10.31 ± 0.57; horizontal dilution of precision 0.85 ± 0.03; signal to noise ratio 433 ± 16 dB-Hz (6). After complete warm-up including maximal acceleration sprints over shorter distances, participants performed five 40-m sprints with at least 3 min of passive recovery. Subjects began each sprint from a static standing start position and were instructed to run the 40-m distance as fast as possible.

Data processing

35 sprints (5 sprints by subject) were analyzed with GPS and linear encoder data collected simultaneously. A 0.2 m/s threshold was used to identify sprint start on raw speed data for both systems. For each trial and each system, a 1-s moving average was used to smooth raw speed data, and the end of the sprint acceleration was identified when processed speed went down to 97.5% of the maximal sprint speed (based on the moving average) right after the start of the deceleration phase. Then, data processing of the force-velocity profiles was performed using a custom-made Excel spreadsheet and the reference procedure validated against force plate data by Samozino et al. and Morin et al. (2,3). Briefly, running speed raw data were fitted with the following mono exponential equation (Figure 1):

$$V_{\mathrm{H}}(t) = V_{\mathrm{Hmax}} \cdot (1 - e^{-(t-d)/\tau})$$

where V_{Hmax} is the maximal sprint velocity reached at the end of the acceleration, Tau (τ) is the acceleration time constant and d the time delay used to extrapolate the entire speed-time model between the 0.2 m/s threshold and the actual start at time = 0 s (2). On this basis, the acceleration associated with the running velocity and the component of the ground reaction force in the direction of motion (i.e. antero-posterior in the horizontal direction of running F_H) over time were computed using basic Newtonian laws of motion (2,3) as shown in Figure 2. Finally, F_{H0} (corresponding to the maximal theoretical force output in the horizontal direction) and V_{H0} (corresponding to the maximal theoretical running velocity capability of the athlete) were obtained as the axes intercepts of the linear relationship between force and velocity over time in the overall direction of motion.

Statistical analyses

All data are presented as mean and standard deviation (SD). Speed-time and force-velocity relationship key variables obtained with both devices were compared using random error (1.96 x standard deviation of the difference between both devices), limits of agreement (bias + random errors) and systematic error (mean difference between both devices) (7). Also, after normality distribution test (Shapiro-Wilk test), differences between devices data were assessed with t-test or Wilcoxon test and inter-device correlations were tested. Finally, the inter-trial reliability for each variable and each device was quantified using the coefficient of variation (CV in %) computed for the five trials.

Results

The agreement between devices is illustrated in Figure 1 for a typical athlete and supported by a nearly perfect correlation for V_{Hmax} (r = 0.98, p<0.001), while τ showed a large correlation (r = 0.69, p<0.001). Figure 2 shows the agreement between devices regarding V_{H0} which was almost perfect (r = 0.96, p<0.001) while it was only moderate for F_{H0} (r = 0.46, p<0.001) (8). All inter-devices comparison results are shown in Table 1.

Finally, the inter-trial variability was low and close between the two devices (Table 2): average coefficients of variation between all trials (for both devices) for τ, V_{Hmax}, F_{H0} and V_{H0} were all < 4.7 ± 2.4%.

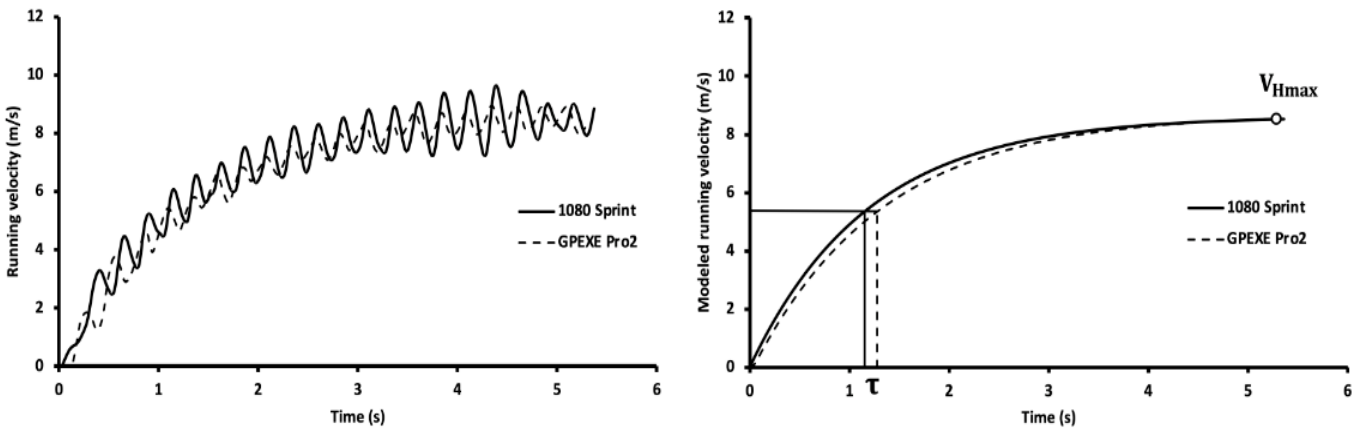

Fig. 1. **Raw horizontal velocity simultaneously recorded by the 1080 Sprint (333 Hz) and the GPEXE Pro2 (18.18 Hz) systems during a 40-m sprint for a representative subject, and their corresponding exponential modelled velocity (including time delay)**

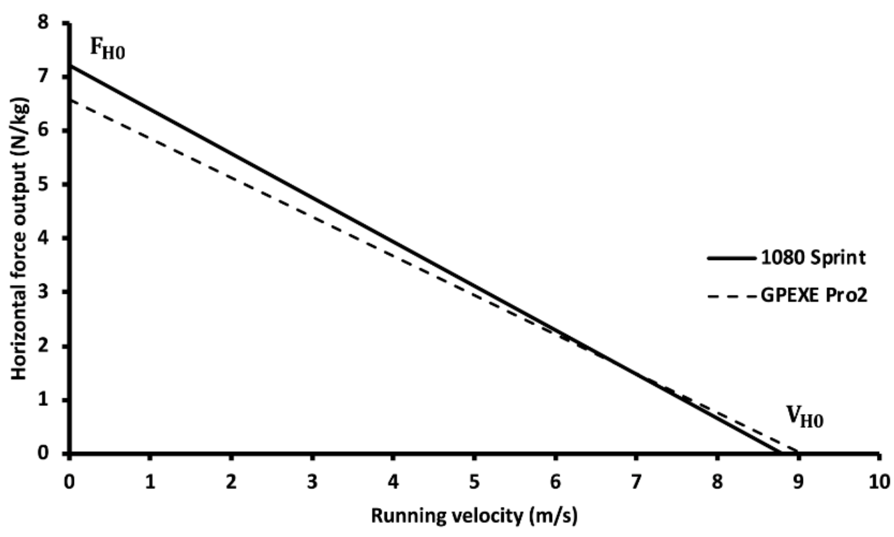

Fig. 2. **Sprint acceleration force-velocity linear relationship based on data for the same typical and representative subject as in Figure 1.**

Table 1. Mean ± SD of the main mechanical variables and comparison between the 1080 Sprint and the GPEXE Pro2.

	1080 Sprint	GPEXE Pro2	Ratio of GPEXE Pro2/1080 Sprint	Systematic error (Mean of inter-device differences)	Random error (1.96 x SD inter-device difference)	95% agreement limits
Tau (s)	1.18 ± 0.07	1.34 ± 0.09	1.13	-0.153	0.126	(-0.279 ; -0.028)
V_{Hmax} (m/s)	8.58 ± 0.36	8.67 ± 0.43	1.01	-0.082	0.228	(-0.310 ; 0.146)
F_{H0} (N/kg)	7.25 ± 0.49	6.42 ± 0.43	0.89	0.84	0.57	(0.266 ; 1.405)
V_{H0} (m/s)	8.76 ± 0.38	9.04 ± 0.48	1.03	-0.28	0.29	(-0.572 ; 0.012)

Table 2. Inter-trial coefficient of variation for the 1080 Sprint and the GPEXE Pro2.

	Coefficient of variation (%)	
	1080 Sprint	GPEXE Pro2
Tau (s)	3.1 ± 1.9	4.7 ± 2.4
V_{Hmax} (m/s)	1.1 ± 0.5	1.5 ± 0.7
F_{H0} (N/kg)	2.9 ± 1.6	3.7 ± 2.1
V_{H0} (m/s)	1.2 ± 0.5	1.7 ± 0.8

Discussion

This comparison of sprint acceleration speed-time curve and derived force-velocity outputs obtained simultaneously with a GPS (GPEXE Pro2) and a linear encoder (1080 Sprint) device overall showed a moderate bias for τ (mean of 11.4 ± 4.3 %) and F_{H0} (mean of 13.1 ± 4.80 %), which shows an overall underestimation of the output variable F_{H0} with the GPS system. Contrastingly, the results showed a very high degree of agreement between devices for the V_{Hmax} (average bias of 1.18 ± 1.01 %) and V_{H0} (average bias of 3.05 ± 1.49 %) variables. Finally, a similarly low inter-trial variability was observed for both devices (Table 2).

These results suggest that the models of GPS and linear encoder devices used in this study are both suitable for sprint acceleration force-velocity profiling following the computational approach proposed by Samozino et al. (2,3). With each device, inter-trial reliability suggests that inter- and intra-athlete comparisons are possible and reliable (for example to assess changes over time, training or detraining effects). However, while V_{Hmax} and V_{H0} data obtained with these devices were very close, these data cannot be considered interchangeable for early acceleration variables τ and F_{H0}. For the latter variables, caution should also be used when comparing testing or research results obtained with these two devices separately. These results will help practitioners and researchers better design their training or research protocols, and better interpret the results from different studies using different technologies for assessing sprint speed-time data and the subsequently computed force-velocity profile outcomes.

Practical Applications

- If different types of sprint measurement devices as the 1080 Sprint and the GPEXE Pro2 are used for speed-time and force-velocity profile assessment, outcomes from different devices should not be compared (without specific preliminary study) as devices are may very likely not be interchangeable.
- For each of the systems tested, the high goodness of fit of the raw speed-time data with the exponential model, and the low and comparable inter-trial variability suggest that both the 1080 Sprint and the GPEXE Pro2 systems can be used in practice for inter- and intra-athlete comparisons.

Limitations

The main limitation of this study is the absence of a gold standard for running speed measurement. Even if the aim of the study was to compare the 1080 Sprint linear encoder and the GPEXE Pro2 GPS systems for speed-time and force-velocity assessment, it could have been interesting to also use either force platforms installed into the running track or a motion capture system to better understand the sources of inter-device differences observed for τ and F_{H0} (2,3,6). Finally, and importantly, the results presented here are specific to the GPS model used in this study, and do not apply to other GPS systems.

Conflict of interest

Author Cristian Osgnach is a scientific consultant for Exelio SRL, the company which produces the GPS units used in this study. Other authors have no conflict of interest to declare.

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Data availability

Data made available to all interested researchers upon request.

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