Force velocity profiling with GPS: is it reliable?

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FVP | Reliability | Automatic

Headline

Due to the importance of neuromuscular qualities (i.e. strength and speed) for soccer players (1), training and monitoring these keys variables is crucial. Recently, force-velocity profiling has been developed in order to accurately assess the ability of a player to produce horizontal force (2). To calculate the profile, practitioners need to use several devices such as a radar gun or timing gates prior to computing the data in a specifically designed spreadsheet. However, in the context of an elite sport environment, time is scarce and it may be difficult for practitioners to allocate specific testing sessions (3) that can last up to 90 min to test 25 players and an equivalent time to process and analyse the data.

The use of micro technology such as Global Positioning System (GPS) devices could partially solve this problem as the technology becomes more accurate. While the potential of GPS devices to assess force-velocity profiles seems promising, the reliability of this approach is yet to be investigated.

Therefore, the aim of the present study was to assess the reliability of force-velocity profile key variables (F0, V0 and maximal Power) assessed via GPS.

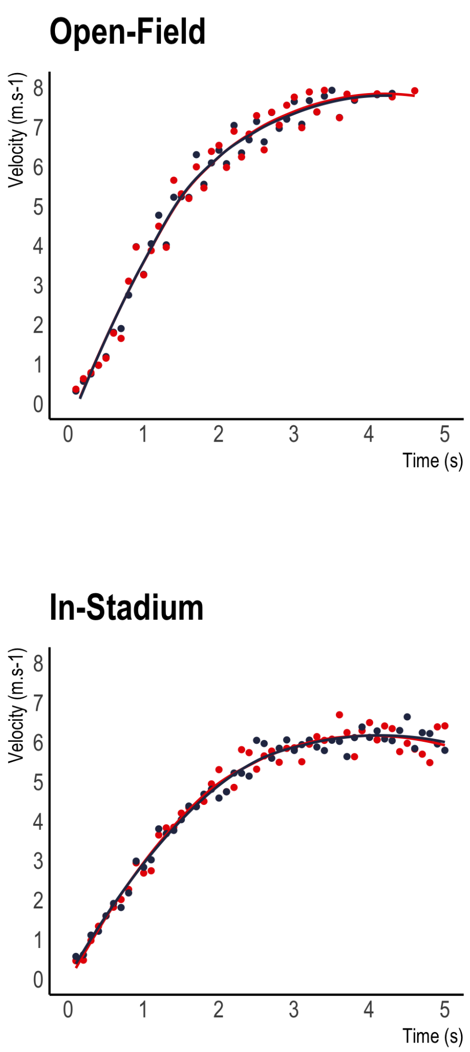

Fig. 1. An example of two GPS signal from the same sprints are shown for open-field and in stadium

Method

Participants. Four recreational athletes were recruited for this study. Local institution ethics clearance was obtained, and this study conformed to the recommendations of the Declaration of Helsinki. Written informed consent of all participants was obtained prior to the beginning of the study. To ensure confidentiality, all performance data were anonymized.

Study Design. A between-devices reliability protocol was conducted to assess the reliability of force-velocity profile derived from the GPS signal during maximal sprint running. Each testing session consisted of a 10-min standardized warm up followed by a force-velocity profile assessment (40m sprint at 90-100% maximal speed). Similar to the design used in a precedent study (4). The session was replicated in two locations: 1) open field pitch (Marcoussis, France) and Stadium (Stade de France, Saint Denis, France) to ascertain the potential effect of stadium structure on GPS signal.

Force-velocity profile testing and data processing. Participants wore the GPS units (Apex, StatSports, Dublin, Ireland) in a specifically designed vest allowing the GPS units to be situated side-by-side 10cm apart. Regarding the force-velocity profile assessment, participants performed 3 sprints over 40 m interspersed by 10-min of passive recovery. Players began each sprint from a static standing start position and were instructed to run between 90-100% of their maximal speed.

36 pairs of sprints per location were analysed. Data processing of the force-velocity profiles were performed using R (Version 4.0.2, R Foundation for Statistical Computing) using a custom built R script (5). Three variables were used for the reliability analysis:

1) maximal horizontal force (F0 [N.kg-1]) corresponding to the maximal force output (per unit body mass) in the horizontal direction; 2) theoretical maximal velocity (V0 [m.s-1]) defined as the sprint-running maximal velocity capability of the athlete and 3) maximal horizontal power (Pmax [W.kg-1]) representing the maximal power-output capability of the athlete in the horizontal direction (per unit body mass) during sprint acceleration (2).

Statistical analysis

All data were first log-transformed to reduce bias arising from non-uniformity error. The between devices reliability of the

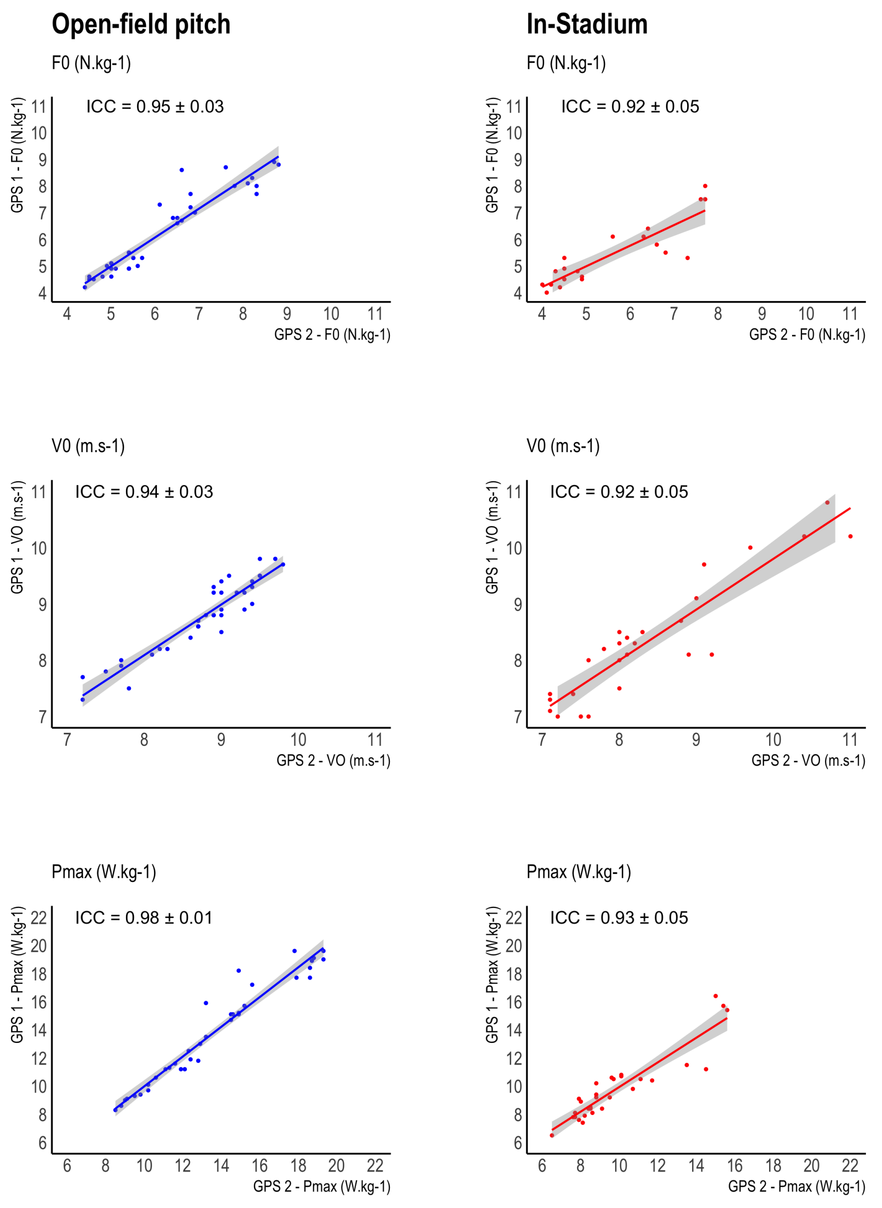

Fig. 2. Between-device linear regression are provided for F0, V0, Pmax for each condition (open field vs in-stadium).

Table 1. Between devices reliability analysis for force-velocity profile related variables.

Condition	Open Field pitch			In-Stadium		
	F0 (N.kg-1)	V0 (m.s-1)	Pmax (W.kg-1)	F0 (N.kg-1)	V0 (m.s-1)	Pmax (W.kg-1)
Standardized (TE 90%CL)	0.25 ± 0.05	0.26 ± 0.05	0.16 ± 0.03	0.30 ± 0.07	0.30 ± 0.07	0.29 ± 0.07
TE as CV (CV[%] 90%CL)	5.6 ± 1.2	2.0 ± 0.4	4.3 ± 0.9	7.8 ± 1.8	7.6 ± 1.8	6.6 ± 1.5
Intraclass Coefficient (90%CL)	0.95 ± 0.03	0.94 ± 0.03	0.98 ± 0.0.1	0.92 ± 0.05	0.92 ± 0.05	0.93 ± 0.05

TE: Typical Error; CV: Coefficient of Variation; SWC: Smallest Worthwhile Change; Cl: Confidence Limits.

force-velocity profile was assessed by calculating the typical error of measurement expressed as a coefficient of variation (CV, 90% CI), standardized typical error (TE) and intraclass coefficient (ICC) with a specific spreadsheet (6).

Results

The reliability results for force-velocity profile variables are summarised in Table 1. The linear regressions assessing the between device and stadium reliability are presented in Figure 1.

Discussion

In this study, we showed 1) trivial-to-small typical error and good-to-very good between device intraclass coefficients for both conditions and 2) slightly better reliability in open-field environment (pitch) compare with stadiums. These results are promising and open up new possibilities for staff wishing to assess force-velocity profiles more frequently in practice.

Overall, trivial to small standardised typical error for V0, F0 and Pmax were observed in both locations (Table 1). This is the first study verifying inter-unit reliability of force-velocity profiles measured by GPS. Previous research identified Apex GNSS models to be reliable when evaluating peak velocity from 5 to 30 m, partially confirming our results (7). Additionally, our results are comparable with studies using a radar gun (8) and timing gates (9), confirming the potential of GPS devices to assess force velocity profiles.

Secondly, we checked if the results were consistent across different locations (i.e. open-field vs in-stadium) (Figure 1 and 2). Compared to the open-field condition, the stadium presented a slightly lower reliability (Table 1). This suggests the stadium structure (i.e. roof and metallic architecture) can affect GPS signal quality and therefore the testing environment should be taken into account to ensure the highest quality of data is obtained. As TE decreases by a factor of $\sqrt{n}$ (10), we would recommend increasing the number of trials to improve the signal-to-noise ratio and in turn the ability to detect changes in performance in-stadium. However, practitioners can remain confident that GPS devices are reliable for the assessment of force-velocity profiles recorded from in-stadium or open-field pitches.

Overall testing physical qualities is time consuming especially in elite team sport environments where testing opportunities are scarce as time to train is already limited. These findings are very important for practitioners who want to assess force-velocity profiles routinely but are constrained due to training schedules. Indeed, the present methodology allows for the testing of a full team within a training session (e.g. 2*40m sprint altogether at the end of a warm-up) instead of the usual 90 min required using traditional methods (e.g. timing gates, radar gun). However future research should investigate the validity of the outcome variables against a radar gun in addition to using elite populations to confirm that such approaches can be implemented in practice.

Practical Applications

- Between-device standardised TE of key force-velocity profile variables (F0, V0, and Pmax) is trivial to small suggesting that force-velocity profiles can be assessed from GPS instead of radar.
- While we recommend the evaluation of force-velocity profiles is performed in an open-field area to ensure the highest data quality, in-stadium data reported good reliability.

Limitations

- While we have demonstrated good between-device reliability, investigation of the concurrent validity with a radar gun is required.
- The data were collected from recreational athletes. Data collected with elite players is necessary to see if the reliability of the test/procedure allow to detect meaningful changes (smallest worthwhile change) in elite athletes.

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References

1. Improving acceleration performance in football players – JB Morin, PhD – Sport Science [Internet]. [cited 2020 Jul 22]. Available from: https://jbmorin.net/2018/08/11/improving-acceleration-performance-in-football-players/

2. Morin JB, Samozino P. Interpreting power-force-velocity profiles for individualized and specific training [Internet]. Vol. 11, International Journal of Sports Physiology and Performance. Human Kinetics Publishers Inc.; 2016 [cited 2020 Jul 22]. p. 267–72.

3. Leduc, C, Tee, J, Lacome, M, Weakley, J, Cheradame, J, Ramirez, C, Jones B. Convergent validity, reliability and sensitivity of a running test to monitor neuromuscular fatigue. Int J Sport Physiol Perform. 2020;in press.

4. Lacome M, Peeters A, Mathieu B, Bruno M, Christopher C, Piscione J. Can we use GPS for assessing sprinting performance in rugby sevens? A concurrent validity and between-device reliability study. Biol Sport [Internet]. 2019 Mar [cited 2019 Mar 29];36(1):25–9.

5. Calculating Force-velocity profile assess through GPS devices in Soccer: From labouring to automatic process - mathlacome.com [Internet]. [cited 2020 Jul 22].

6. Hopkins WG. Spreadsheets for analysis of validity and reliability. Retrieved from http://sportscience.sportsci.org. 2015.

7. Beato M, de Keijzer KL. The inter-unit and inter-model reliability of GNSS STATSports Apex and Viper units in measuring peak speed over 5, 10, 15, 20 and 30 meters. Biol Sport. 2019;36(4):317–21.

8. Simperingham KD, Cronin JB, Ross A. Advances in Sprint Acceleration Profiling for Field-Based Team-Sport Athletes: Utility, Reliability, Validity and Limitations. Sport Med. 2016;46(11):1619–45.

9. Haugen TA, Breitschädel F, Samozino P. Power-Force-Velocity Profiling of Sprinting Athletes: Methodological and Practical Considerations When Using Timing Gates. J strength Cond Res. 2020;34(6):1769–73.

10. Haugen T, Buchheit M. Sprint Running Performance Monitoring: Methodological and Practical Considerations. Sport Med. 2015