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BRIEF REPORT

Monitoring Accelerations With GPS in Football: Time to Slow Down?

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The aims of the current study were to examine the magnitude of between-GPS-models differences in commonly reported running-based measures in football, examine between-units variability, and assess the effect of software updates on these measures. Fifty identical-brand GPS units (15 SPI-proX and 35 SPI-proX2, 15 Hz, GPSports, Canberra, Australia) were attached to a custom-made plastic sled towed by a player performing simulated match running activities. GPS data collected during training sessions over 4 wk from 4 professional football players (N = 53 files) were also analyzed before and after 2 manufacturer-supplied software updates. There were substantial differences between the different models (eg, standardized difference for the number of acceleration >4 m/s^2 = 2.1; 90% confidence limits [1.4, 2.7], with 100% chance of a true difference). Between-units variations ranged from 1% (maximal speed) to 56% (number of deceleration >4 m/s^2). Some GPS units measured 2–6 times more acceleration/deceleration occurrences than others. Software updates did not substantially affect the distance covered at different speeds or peak speed reached, but 1 of the updates led to large and small decreases in the occurrence of accelerations (–1.24; –1.32, –1.15) and decelerations (–0.45; –0.48, –0.41), respectively. Practitioners are advised to apply care when comparing data collected with different models or units or when updating their software. The metrics of accelerations and decelerations show the most variability in GPS monitoring and must be interpreted cautiously.

***Keywords**:* global positioning systems, between-unit variability, interunit variations, deceleration, high-speed running, team sports

In recent years, the use of global position systems (GPS) has grown exponentially in team sports.[1] Distance covered at various speeds and the occurrence of high-speed runs, accelerations, and decelerations are the most common measures reported by sport scientists.[1] The acceptable validity and within-unit reliability of most commonly used systems have been reported.[2–4] There are, however, other practical aspects that still need to be considered, especially when dealing with a large number of players over long periods of time. First, the use of the same unit for a particular player is often practically difficult (eg, number of players > number of GPS units), so examining the variability between different models and units from the same brand is essential.[4] Second, while match and training GPS databases are commonly used to track the development of players over time, the effects of software updates on GPS-related measures is still unknown. The aims of the study were to examine possible between-GPS-models differences in commonly reported running-based measures in football, examine between-units variability, and assess the effect of software updates on these measures.

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Methods

Variability Between Models and Units

Fifty GPS units from the same manufacturer (15 SPI-proX, chip version 2.3.4, and 35 SPI-proX2 [17 SPI-proX2a, chip version 2.6.1, and 18 SPI-proX2b, 2.6.4], 15 Hz, GPSports, Canberra, Australia) were securely attached to a custom-made lightweight plastic sled (78 × 54 × 21 cm) in which the units could be vertically aligned with 3 cm between them. The sled was attached to a team-sport player, using a speed-training harness, who dragged it while performing a standardized

30-minute running routine (repeated jogging/running fast and sprinting [~0–60 m] phases). The standardized routine was repeated on 2 consecutive days (1 day at 1:30 PM and the other day at 8:00 AM to compare different GPS settings with respect to satellite positions) on an outdoor synthetic soccer pitch. Pilot testing showed that the maximal acceleration achieved with the sled was similar to what is reported for team-sport players during games (3–5 m/s^2).[1] GPS data were analyzed with Team AMS-R1-2012.9 software. Total distance, distance traveled above 14.4 km/h and 25.1 km/h, peak acceleration, number of accelerations (Acc) above 3 and 4 m/s^2, peak speed reached, and number of decelerations (Dec) above 3 and 4 m/s^2 were computed.

Software Updates

The GPS variables (plus Acc >1.5 m/s^2) were also collected during training sessions over 4 weeks in 4 professional football players and were analyzed before (R1-2011-B4) and after 2 software updates (R1-2011-16-P12 and R1-2012.9; N = 53 player files).

Statistical Analysis

Between-units variations were assessed with a coefficient of variation (CV). Between-models differences and the effect of software updates were examined using standardized differences with 90% confidence limits (CL).[5]

Results

Variability Between Models and Units

The average number of satellites per unit was 10.6 (90%CL [10.4, 10.8], range 10–12), and the sky was perfectly clear on both testing days. The players' movement patterns were comparable between day 1 and 2 (<1% difference in total distance and <3% difference in distance traveled >14.4 km/h and the number of Acc >3 and 4 m/s^2). On both days, there were substantial differences in some variables between the 3 different GPS models and very large between-units variations in each measure. Some GPS units measured 2 to 6 times more Accs and Decs than others (Figure 1). The between-units variations ranged from 1% (peak speed) to 56% (Dec >4 m/s^2).

Software Update

The software updates did not substantially affect the distance covered at different speeds or peak speed reached. The second update, however, led to large and small decreases in the occurrence of Accs and Decs, respectively (Table 1).

Discussion

The main findings of the current study were that there are very large variations in common GPS measures (particularly Accs and Decs) between models and units from the same manufacturer with similar chip versions, and analysis of the same data files with different software versions showed substantial differences in the occurrence of Accs and Decs.

When comparing common GPS measures obtained simultaneously from 50 units attached to the same sled, we observed small to very large between-models differences and very large between-units variations (CV 1–56%, Figure 1). These between-units variations were greater than those previously reported for total distance (<3%, 2 units[4]) but within the range of those observed for Acc and Dec (9% to 30%, 2 units[3]). Differences in the number of GPS units simultaneously analyzed (2 vs 50), brand, data treatment (manufacturer's software vs custom-made software), and protocol (players[3] vs trundle wheel with platform[4] vs sled) should be considered. The present between-models and -units variations were so large for Accs and Decs that they question the usefulness of these measures. Accordingly, peak speed reached (1%) and, to a lower extent, the distance >25 km/h (6%), which can also inform on high-speed-running demands, may therefore be regarded as more useful measures.[2,6]

The second software update led to substantial decreases in Accs and Decs (Table 1). This inconsistency is problematic for practitioners managing game/training databases over time. The choice of updating the software is therefore left to the practitioners, who would have to balance the possible benefit of an improved analysis with the potential loss of consistency with historical data.

In conclusion, practitioners are strongly advised to apply care when comparing data collected with different models and/or units[4] and/or that are analyzed with different software versions. This is problematic in practice, especially when dealing with historical data collected on a large number of players. The present results question the usefulness of GPS monitoring in team-sport players when using the brand and models assessed in this study. In particular, practitioners in the field should be cautious when using acceleration-derived indices to monitor and guide training.

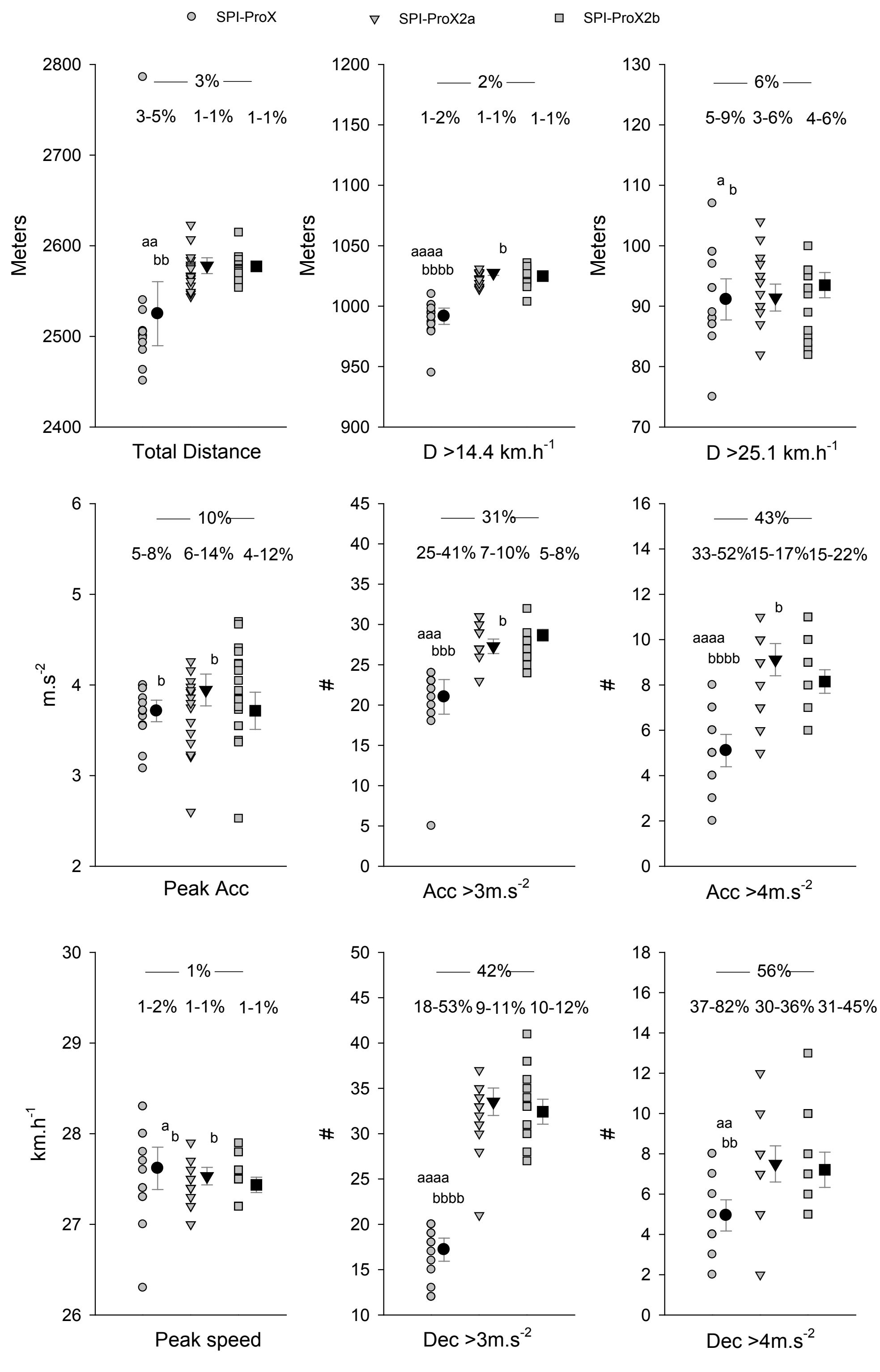

Figure 1 — Total distance, distance traveled above 14.4 km/h (D >14.4 km/h) and 25.1 km/h (D >25.1 km/h), peak acceleration (Peak Acc), number of accelerations above 3 m/s^2 (Acc >3 m/s^2) and 4 m/s^2 (Acc >4 m/s^2), peak speed reached, and number of decelerations above 3 m/s^2 (Dec >3 m/s^2) and 4 m/s^2 (Dec >4 m/s^2) measured simultaneously by 50 GPS units on day 2. Black dots indicate mean value with 90% confidence intervals on day 2. For clarity, individual data points from day 1 are not provided. Numbers (%) indicate the range of between-units standard deviation (expressed as a coefficient of variation) over the 2 consecutive testing days. Letters *a* and *b* indicate a substantial difference versus SPI-ProXa and SPI-ProXb, respectively, with the number of letters standing for small (1 letter), moderate (2 letters), large (3 letters), and very large (4 letters) differences. If the 90% confidence limits overlapped small positive and negative values, the magnitude was deemed unclear; otherwise that magnitude was deemed the observed magnitude.[5]

Table 1 GPS-Related Training Running Variables With Respect to Software Update, Mean ± SD, N = 52

	Before update	Update 1	Update 2
Software version	R1-2011-B4	R1-2011-16-P12	R1-2012.9
Total distance (m)	5849 ± 1603	5693 ± 1586	5849 ± 1603
Distance >14.4 km/h (m)	728 ± 373	703 ± 364	728 ± 373
Distance >25.1 km/h (m)	6.65 ± 10.3	6.63 ± 10.3	6.65 ± 10.3
Number of runs >25.1 km/h	0.33 ± 0.58	0.33 ± 0.58	0.33 ± 0.58
Peak speed (km/h)	25.43 ± 3.13	25.43 ± 3.13	25.43 ± 3.13
Number of accelerations >1.5 m/s^2	251 ± 65	251 ± 65	177 ± 53↓[L]
Number of accelerations >3 m/s^2	26.6 ± 11.7	26.6 ± 11.7	20.2 ± 10.0↓[S]
Number of accelerations >4 m/s^2	0.85 ± 1.24	0.85 ± 1.24	0.44 ± 0.80↓[S]
Number of decelerations >1.5 m/s^2	181 ± 52	181 ± 52	158 ± 51↓[S]
Number of decelerations >3 m/s^2	19.7 ± 8.2	19.7 ± 8.2	16.8 ± 8.0↓[S]
Number of decelerations >4 m/s^2	1.8 ± 1.5	1.8 ± 1.5	1.4 ± 1.3↓[S]

Note: If the 90% confidence limits overlapped small positive and negative values, the magnitude was deemed unclear; otherwise that magnitude was deemed to be the observed magnitude.[5]

[S] Small standardized difference vs previous software version. [L] Large standardized difference vs previous software version.

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