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Technical note

Validity and reliability of GPS devices for measuring movement demands of team sports

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Abstract

There is limited information regarding the validity and reliability of global positioning system (GPS) devices for measuring movement during team sports. The aim of this study was to assess the validity and intra-model reliability of different GPS devices for quantifying high-intensity, intermittent exercise performance. Two moderately trained males each completed eight bouts of a standard circuit that consisted of six laps around a 128.5-m course involving intermittent exercise. Distance and speed were collected concurrently at 1-Hz using six GPS devices (2 SPI-10, 2 SPI Elite and 2 WiSPI, GPSports, Canberra, Australia). Performance measures were: (1) total distance covered for each bout and each lap; (2) high-intensity running distance (>14.4 km h^{-1}, HIR); very high-intensity running distance (>20 km h^{-1}, VHIR) during each bout. Peak speed was also measured during a 20-m sprint at the start of each lap of the circuit ($N = 192$). Actual distance was measured using a measuring tape. Mean (±SD) circuit total distance was significantly different between each of the GPS devices ($P < 0.001$); however, all devices were within 5 m of the actual lap distance and had a good level of reliability (coefficient of variation (CV) <5%). The CV for total distance (3.6–7.1%) and peak speed (2.3–5.8%) was good-to-moderate, but poor for HIR (11.2–32.4%) and VHIR (11.5–30.4%) for all GPS devices. These results show that the GPS devices have an acceptable level of accuracy and reliability for total distance and peak speeds during high-intensity, intermittent exercise, but may not be provide reliable measures for higher intensity activities.

Keywords: Match analysis; Training analysis; Team sports

1. Introduction

It is common for sports scientists in high level field-based, team sports to quantify player movements during competition using Global Positioning System (GPS) technology. There is presently limited information regarding the validity and reliability of the various GPS devices for measuring movement during high-intensity, intermittent exercise.[1] Therefore, the aims of this study were to assess: (1) the validity of several GPS devices for measuring distance and peak speed during high-intensity intermittent exercise, and (2) the intra-model reliability of GPS devices for measured running speed and distance in team sport athletes.

2. Methods

Two moderately trained males (age: 32 ± 2 y) each completed eight bouts of a standard circuit that was designed to reflect the movement demands of team sport.[2] Each bout consisted of six laps around a marked 128.5 m running circuit involving walking, jogging, fast running, sprinting and standing still (Fig. 1 available online). One minute was allowed to complete each lap. Each lap was hand timed and feedback was provided to the participant regarding remaining time before the commencement of the next lap. There was 5–15 s recovery between the completion of the circuit and the commencement of the next lap. The participants were instructed to follow the marked course as closely as possible. Distance and speed were collected concurrently during each trial at 1-Hz using six portable GPS devices (2 SPI-10, 2 SPI Elite and 2 WiSPI, GPSports, Canberra, Australia). Each pair of the same model GPS device were tightly packed into a harness next to each

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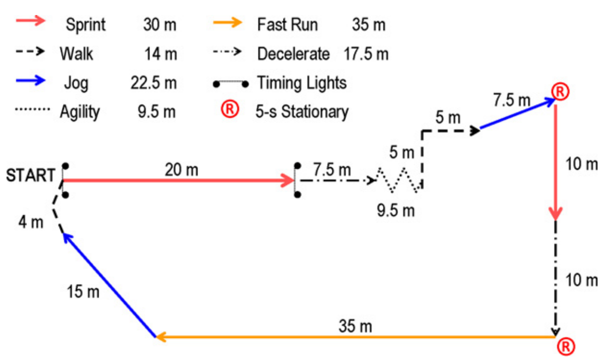

Fig. 1. Diagram of simulated team sport running circuit.

other with their antennas exposed to allow a clear satellite reception.

Primary performance measures were: (1) total distance covered for each bout and each lap ($N = 16$; $N = 96$); (2) low intensity activity distance (<14.4 km h^{-1}, LIA; $N = 32$); high-intensity running distance (>14.4 km h^{-1}, HIR; $N = 32$); very high-intensity running distance (>20 km h^{-1}, VHIR; $N = 32$) during each bout. These speed zones were selected as they reflect the zones previously reported in recent time-motion analysis literature in field-based, team sports[3–5] and were calculated with the manufacturers software. GPS peak speed was also measured during a 20-m sprint at the start of each lap of the circuit ($N = 192$). Actual distance was measured using a measuring tape and sprint performance was measured using timing lights (Swift Sports, Lismore, Australia).

One-way analysis of variance (ANOVA) with Scheffe post hoc testing was used to examine differences in distance and speed measures obtained between different devices and laps. The intra-model reliability (i.e. comparison of data from two GPS devices of the same model) was determined using the typical error expressed as a coefficient of variation (CV) and 90% Confidence Intervals (CI). Significance was set at $P < 0.05$.

3. Results

Table 1 shows that both the lap and bout distance were significantly different between the various GPS devices ($P < 0.001$). The SPI-10 devices recorded lower peak speeds than the SPI Elite devices ($P < 0.002$). The total distance measures from the SPI-10, SPI Elite and WiSPI were $-4.1 \pm 4.6\%$, $-2.0 \pm 3.7\%$ and $0.7 \pm 0.6\%$ from the true bout distance, respectively. The bout total distance for the SPI-10 was different to the WiSPI ($P < 0.001$). The GPS peak speed was correlated with 20 m sprint time for all devices ($r = -0.40$ to -0.53, $P < 0.001$). The intra-model reliability for the performance measures with each of the GPS devices are also shown in Table 1.

4. Discussion

In agreement with previous research,[6] all GPS devices in this study demonstrated a good level of accuracy (<5%) for the actual measured distance. It is possible that some of the measured error in total distance may be associated to differences between the measured distance and the actual course

Table 1
The performance variables (mean ± SD) and the intra-model reliability measures (coefficient of variation ± 90% CI) for the performance variables from the three GPS devices.

	GPS device		
	SPI-10	SPI Elite	WiSPI
Performance variables			
Distance			
Lap (m)	123.2 ± 8.3[b,c]	126.1 ± 5.6[a,c]	129.1 ± 8.2[a,b]
Bout (m)	739 ± 35	756 ± 29	776 ± 44[a]
Speed zones			
VHIR (m)	60 ± 18	83 ± 18[a]	82 ± 19[a]
HIR (m)	175 ± 51	147 ± 47	145 ± 45
LIA (m)	565 ± 37[b]	524 ± 32	553 ± 61[b]
Peak speed (km h^{-1})	21.3 ± 2.0[b,c]	21.9 ± 1.7	21.7 ± 1.8
Intra-model coefficient of variation			
Distance			
Lap (m)	6.4 (5.7–7.4)	4.0 (3.6–4.5)	7.2 (6.4–8.4)
Bout (m)	4.5(3.5–6.6)	3.6 (2.8–5.2)	7.1 (5.3–10.9)
Speed zones			
VHIR (m)	30.4 (22.8–46.4)	15.4 (11.7–22.9)	11.5 (11.5–25.4)
HIR (m)	32.4 (24.3–49.7)	11.2 (8.6–6.5)	20.4 (15.1–32.5)
LIA (m)	5.3 (4.1–7.7)	4.3 (3.3–6.2)	12.5 (9.3–16.6)
Peak speed (km h^{-1})	5.8 (5.2–6.6)	2.3 (2.1–6.6)	4.9 (4.3–5.7)

[a] Significantly different to SPI-10 ($P < 0.05$).
[b] Significantly different to SPI Elite ($P < 0.05$).
[c] Significantly different to WiSPI ($P < 0.001$).

taken by the participant rather than the GPS derived error. However, the SPI-10 recorded lower total distance for circuit laps and bout distance compared to the other devices. These results indicate that the newer models of GPS devices generally appear to have greater accuracy and reliability than the older SPI-10 models. The improved accuracy may be attributed to custom algorithms that use data from the inbuilt 100 Hz accelerometer in the newer models to correct the shortcomings of 1 Hz GPS. Additionally, the difference in distance measurements suggests that results from different GPS devices should not be used interchangeably when analysing high intensity running.

The intra-model reliability for total distance travelled during each bout and peak speed measures were low for each of the models assessed. The CV for the LIA and HIR were moderate but did increase for the higher speed zones. The large CV for all the models examined suggest that GPS devices that sample at 1 Hz may be unable to detect important changes in running distances at speeds >20 km h^{-1}.

The moderate relationship between 20 m sprint times and GPS peak speeds provides evidence to support the construct validity of using GPS to assess sprint performance in team sports when sprints are longer than 20 m. A limitation of this study, however, is that mean sprint speed was only assessed over a standard distance (20 m) and that true peak speed was not directly measured. Quite often, short sprints and brief maximal accelerations of >1 s are completed in team sports. Therefore it is possible that important data may be missed by GPS devices with a 1-Hz sampling rate. This may also explain the poor level of reliability for the higher intensity activities and suggests that future research should examine the efficacy of using increased sampling rates to measure time-motion characteristics in team sports.

In summary, the GPS devices in this study have an acceptable accuracy and reliability for most performance measures relevant to team sports that demand brief, intermittent sprinting over a non-linear course. However, the poor level of intra-model reliability for VHIR is a concern as these measures have been shown to be important measures of match running performance.[3–5] We suggest that the level of reliability of these measures be taken into account when interpreting changes in movement demands of team sports when using GPS data.

Practical implications

- The GPS devices tested in this experiment provide accurate and reliable information on total distance travelled during team sport running patterns; however data from different devices should not be used interchangeably.
- GPS devices that record at 1-Hz may not provide accurate information regarding high-intensity activities, especially if these are completed over a non-linear path.

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