The validity and reliability of a global positioning satellite system device to assess speed and repeated sprint ability (RSA) in athletes

José C. Barbero-Álvarez a,*,1, Aaron Coutts b, Juan Granda a, Verónica Barbero-Álvarez a, Carlo Castagna c

a University of Granada, Campus of Melilla, Spain
b University of Technology, Sydney, Australia
c Tor Vergata University, Italy

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Abstract

There is a limited understanding of the validity and reliability of commercially available global positioning satellite (GPS) devices for assessing repeated sprint performance in athletes. The aims of this study were to assess the convergent validity and the test–retest reliability of a GPS device for measuring repeated sprint ability test (RSAT) variables. Two groups participated in this study, a group of 21 physical education students (age: 20.2 ± 2.3 years, stature: 1.75 ± 0.42 m, body mass: 68.0 ± 6.8 kg) and a second group 14 elite junior soccer players (age: 14.5 ± 1.2 years, stature: 1.60 ± 0.09 m, body mass: 57.7 ± 3.8 kg) volunteered to participate in this study. Convergent validity was assessed as the correlation between sprint performance (15 and 30-m) using both timing lights and a portable GPS device during a RSAT (7 × 30-m sprints with 30-s of active recovery). The 7 × 30-m RSAT test–retest reliability using GPS device was assessed in elite junior soccer players repeating the test 1 week apart and expressing reliability as a coefficient of variation. Results showed a strong correlation between peak speed measures with the GPS device and RSAT performance measured with timing lights for the 15-m ($r^2 = 0.87$, $p < 0.001$, $N = 147$) and 30-m ($r^2 = 0.94$, $p < 0.001$, $N = 147$) splits, respectively. There was a low coefficient of variation for summated maximal speed (1.7%) and peak speed (1.2%) during the 7 × 30-m RSAT, but high variation for the percentage decrement score (36.2%). These results provide evidence to support the use of the GPS device as an alternative measure to assess repeated sprint performance but suggest a percentage decrement score is not a reliable measure of RSAT performance.

Keywords: GPS technology; High intensity exercise; Fitness assessment; Soccer; Team sports

1. Introduction

The ability to perform repeated sprints with minimal recovery between sprint bouts, termed repeat sprint ability (RSA), is an important capacity for team sport athletes.1 Many studies have shown that sprinting, RSA and the ability to exercise at high intensity are important capacities for increased performance in many team sports.1,2 Indeed several match analysis studies from a variety of team sports have shown that improved sprint performance and ability to repeat efforts at high intensity are associated with playing at higher competitive levels.1,3,4 Moreover, Rampinini et al.1 recently established the convergent validity of RSA by showing that it was correlated to several match-related physical performance in top-level professional soccer players. Collectively, these studies show that the assessment of speed and RSA is important for field-based team sports.

Whilst it is well known that RSA is important for team sports, it has typically been difficult to assess in the field-setting using conventional methods. The most common method for assessing RSA in the field-setting has been with the electronic timing gates.5 However, since this method often allows for a limited number of players to be assessed simultaneously, measuring RSA in large groups of athletes or entire teams can be time consuming and often difficult to
implement. Recently, GPS tracking systems have been used to assess the physical demands of team sports competition and training. The validity of GPS devices for measuring distance travelled in team sport and endurance athletes have been described previously and there have been two previous studies that have assessed the validity of GPS devices for assessing speed in active subjects. However, to the authors knowledge there is currently no research regarding the suitability of GPS devices to monitor RSA.

Recent developments in GPS technology offer potential to overcome logistical issues and restrictions associated with using electronic timing gates to assess sprint performance. Additionally, GPS technology is also commonly being used to monitor player external workload during matches and training in many outdoor team sports (Australian rules football, soccer, rugby, hockey). Therefore, if this technology could be used to reliably assess RSA performance it may be a convenient testing tool. For example, the time spent collecting could be reduced and tests could be conducted within a normal training session with minimal disruption. At present however, there is a limited understanding of the validity and reliability of commercially available GPS for assessing sprint and RSA performance in athletes. Therefore, the aims of this study were: (1) to assess the convergent validity of using the GPS device for measuring running speed in team sport athletes; and, (2) to assess the test–retest reliability of a GPS device for measuring running speed and RSA in team sport athletes.

2. Methods

This study was conducted in two parts. Firstly, the correlations between peak speed obtained from a GPS device with sprint time (at 15 and 30-m) measured with timing lights was determined. Secondly, we assessed the test–retest reliability of the peak speed, summated peak speed and fatigue index (decrement in maximum speed) measures recorded from the GPS device during a 7 × 30-m repeated sprint ability test (RSAT) conducted 1 week apart. All tests were conducted on a grassed soccer field, away from obstruction from large buildings, structures or vegetation.

Twenty-one physical education students from the University of Granada (age: 20.2 ± 2.3 years, stature: 1.75 ± 0.42 m, body mass: 68.0 ± 6.8 kg) randomly chosen from a population of physically active students and sport team athletes, volunteered to participate in this study. Each subject signed a written consent prior to participation after being informed both orally and in writing about the experimental procedures, the possible risks and benefits of the study. The experimental protocol was approved by the Institutional Research Ethics Committee.

One hundred and forty seven individual sprints were recorded concurrently with the timing lights and a GPSports SPI Elite device (GPSports System, Canberra, Australia). Each sprint was completed as part of a RSAT consisting of seven 30-m sprints with 30-s of active jog recovery (~50 m) between sprints. Players were allowed 20-m to decelerate following each sprint and the subjects rested for approximately 5 s on the start line before commencing each sprint. Each RSAT was conducted in pairs (two players at same time) and verbal feedback was given to inform the subjects of the recovery time remaining between each sprint. The sprint performance was assessed using custom-made infrared light sensors (Omron E3S-CR11, University of Granada, Campus de Melilla, Spain) connected to a personal computer. The light sensors were set at 0-, 15 and 30-m. Briefly, each RSAT was conducted in accordance with the protocol previously used by Reilly et al., but with 30-s of active rest. From a standing start 20-cm behind the starting gates, the two subjects performed seven maximal effort sprints over 30-m, with a 30-s of active rest (running towards the start line) between each sprint. The subjects were instructed before the sprint to produce maximal efforts for every sprint and to not pace themselves. The fastest time (FT), total sprint time to complete the 7 × 30-m sprints (TT) and sprint decrement as fatigue index (FI) were calculated according to Fitzsimons et al. All RSA calculations were made from the data taken at 30-m.

In addition to the timing light measures, during each sprint maximal velocity was concurrently measured with a GPS device. The GPS device was attached to the subjects back according to the manufacturer’s specifications and recorded distance at a frequency of 1 Hz. Criterion performance measure from the GPS system were the peak speed achieved (PS), summation peak speed (∑PS) and the fatigue index (FI_{GPS}) for decrement in maximum speed.

Fourteen young elite soccer players (age: 14.5 ± 1.2 yrs, stature: 1.60 ± 0.09 m, body mass: 57.7 ± 3.8 kg) participated in the second part of this study. A parent or legal guardian of each player signed a written consent after being informed both orally and in writing about the experimental procedures and the possible risks and benefits of the study. The experimental protocol was approved by the Institutional Research Ethics Committee.

To determine the test–retest reliability of the GPS device, each subject completed the 7 × 30-m (with 30-s of jog recovery) RSAT on two separate occasions under the similar experimental conditions described in part one of this study. Since 14 GPS devices were available, all players completed the RSAT together on the same marked outdoor course. Each player completed the second RSAT test 7 days following the first test at the same time of day. All players were instructed to abstain from arduous exercise and maintain a similar food and fluid intake for the 24 h prior to each test. For each test, the players wore the same GPS device (SPI Elite, GPSports System, Canberra, Australia).

3. Statistical analyses

Pearson’s correlation coefficients were then used to assess the relationship between variables. To assess the level of...
reliability of the GPS unit for assessing sprint performance the typical error (TE), coefficient of variation (CV), intraclass correlation coefficient (ICC) and 95% confidence intervals (95% CI) were calculated according to the methods of Hopkins. Analyses were performed using Microsoft Excel® (Microsoft, Redmond, USA) and SPSS (Version 14.0, Chicago, USA). Statistical significance was set at p < 0.05. All data are reported as the mean ± SD unless otherwise stated.

4. Results

Table 1 shows the correlation coefficients between the 30-m RSAT performance variables obtained with GPS device and the timing gates in part one of the study. The CVs and ICC’s for summated maximal speed (CV = 1.7%; 95% CI = 1.2–2.8%; ICC = 0.93, 95% CI = 0.76–0.98) and peak speed (CV = 1.2%, 95% CI = 0.9–2.0%; ICC = 0.97, 95% CI = 0.89–0.99) were low and high, respectively. However, there was a poor CV for the fatigue index (percentage decrement score) obtained from the GPS (CV = 36.2%, 95% CI = 29.6–81.6%; ICC = −0.15, 95% CI = −0.65–0.44).

Table 1
Correlation coefficients between the 7 × 30-m RSAT performance measures obtained with the GPS device and the timing lights (n = 21).

<table>
<thead>
<tr>
<th>Timing lights</th>
<th>GPS measurements (test)</th>
<th>GPS measurements (retest)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak speed (km/h)</td>
<td>Sum maximal speed (SMS)</td>
</tr>
<tr>
<td>Fastest time</td>
<td>−0.93a</td>
<td>−0.98a</td>
</tr>
<tr>
<td>Total sprint time</td>
<td>−0.96b</td>
<td>−0.97a</td>
</tr>
<tr>
<td>Fatigue index</td>
<td>0.11</td>
<td>0.26</td>
</tr>
</tbody>
</table>

4a, b p < 0.001, b p < 0.01.

5. Discussion

The purpose of this study was to examine the convergent validity and reliability of a GPS tracking system to measure RSAT performance. The results of this study demonstrated a strong correlation between peak speeds measured with GPS device during the RSAT and the time taken to complete the 30-m sprint efforts during the RSAT. In agreement with previous research, the present results demonstrate that GPS peak speed allows a valid and reliable estimation of maximal speed when assessed over distances of 15-m to 30-m.

Previous studies have shown that RSA, peak speed and acceleration are important characteristics in team sport athletes. However, team assessment of these qualities in the field-setting may be time consuming. In this study we found a strong relationship between sprint performance variables measured with the GPS and the timing gates, particularly for the 30-m sprint. The present results provide evidence to support the convergent validity of using peak speed measurements during 30-m RSAT sprints with a GPS device. Additionally, the results also demonstrated a good level of test–retest reliability between the sprint and 7 × 30-m RSA performance measures with the GPS device suggesting that this device may be a suitable surrogate measure of sprint performance characteristics in team sport athletes. The present results are similar to those reported in previous studies that have examined variation in RSAT performance in the field and in the laboratory (CVs: 0.7–5.5%). For example, McGawley and Bishop reported CVs of between 2.4% and 5.5% for total work completed during a 5 × 6-s sprint cycle test over five trials. Additionally, Hughes et al. 19 and Sirotic and Coutts reported test–retest CVs of 2.8% (1.9–3.9%) and 2.5% for RSA test performed (i.e. 6 × 6-s and 5 × 6-s with 30 s recovery, respectively) on non-motorised treadmills. In field conditions (i.e. 6 × 30-m sprint), Spencer et al. 16 and Oliver et al. 20 reported CVs of 0.7% and in the range of 1.6–20% for total sprint time, respectively. Collectively, these studies suggest that the GPS device may be used as a surrogate measure of sprint performance when longer sprints are being completed (>30-m). We suggest that future studies be conducted comparing GPS results with speed data obtained with a radar or displacement transducer to establish the true validity of this device for assessing sprint performance.

This study has shown that FI and FIGPS shared only 44% of common variance. This occurrence together with the poor reliability of FI detected with the two measurement methods (i.e. GPS and timing gates) question the use of performance decrement analyses to characterise RSA. These results agree
with previous research that has showed that the RSA fatigue index was less reliable than directly measured performance RSAT variables (CV: 14.9–46%). The poor reliability of fatigue index variables during a RSAT may be due to calculation methods inflating the random variation relative to the magnitude of the measure. However, on the basis of these findings, we suggest that the most appropriate measure of RSA for longitudinal monitoring of athletes is RSA mean sprint time or total sprint time rather than fatigue index measures.

The present results provided evidence supporting the use of peak speed parameters obtained through the use of a GPS device to assess sprint performance. These results combined with the acceptable level of test–retest reliability, support the use of measuring RSAT with a 1-Hz GPS device for assessing sprint performance over distances of 30-m, but not as strongly for 15-m sprints. Indeed, the lower correlation between the GPS peak speed and the time to cover 15-m compared to 30-m suggests that this device may not be as suitable for assessing sprint performance over shorter distances (i.e. <15-m). Therefore, we suggest that coaches and fitness trainers may use GPS devices for a fast evaluation of their team player’s ability to repeat longer distance sprints.

The use of GPS may be a viable alternative to electronic timing lights for assessing sprint performance during a 7 × 30-m RSAT. However, there are some limitations with using this technology that must be considered. Importantly, the GPS device used in this study recorded positional measures each second and this low sampling rate (i.e. 1 Hz) may reduce the sensitivity of these measures, especially over shorter distances. With this device only one or two position samples will be measured with a 1-Hz GPS device during sprints which are common in team sports (i.e. <20-m). More research is required to determine if increased sampling frequency will improve the reliability of the GPS measurement device for quantifying sprint performance and fast accelerations over shorter distances. Future studies should also examine the validity and reliability of using GPS devices to measure speeds and distance travelled with team sport specific running patterns using shorter sprint distances and non-linear movement patterns that are more specific to team sport match play.

**Practical implications**

- GPS devices may be used to assess both single sprint and repeated sprint performance over distances of 30-m.
- The reliability of the GPS devices is sensitive enough to detect relatively small changes in serial measurements of repeated sprint performance when completed over distances of >30-m.
- GPS devices provide a practical alternative to assess repeated sprint performance characteristics in team sport athletes.

**References**

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