Validity and reliability of global positioning systems units (STATSports Viper) for measuring distance and peak speed in sports

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Abstract

Previous evidence has proven that large variability exists in the accuracy of different Global Positioning Systems (GPS) brands. Therefore, any GPS model should be validated independently, and the results of a specific brand cannot be extended to others. The aim of this study is to assess the validity and reliability of GPS units (STATSports Viper) for measuring distance and peak speed in sports. Twenty participants were enrolled (age 21 ± 2 years, weight 73 ± 5 kg, height 1.78 ± 0.04 m). GPS validity was evaluated by comparing the instantaneous values of speed (peak speed) determined by GPS (STATSports Viper 10 Hz, Ireland) with those determined by a radar gun during a 20-m sprint. Data were analyzed using the Stalker (34.7 GHz, USA) ATS Version 5.0.3.0 software as gold standard. Distance recorded by GPS was also compared with a known circuit distance (400-m running, 128.5-m sports specific circuit and 20-m linear running). The distance bias in the 400-m trial, 128.5-m circuit and 20-m trial was 1.99 ± 1.81% and 2.7 ± 1.2%, 1.26 ± 1.04% respectively. Peak speed measured by the GPS was 26.3 ± 2.4 $Km \cdot h^{-1}$ and criterion was 26.1 ± 2.6 $Km \cdot h^{-1}$, with a bias of 1.80 ± 1.93%. The major finding of this study was that GPS did not underestimate the criterion distance during a 400-m, 128.5-m circuit and 20-m trial, as well as peak speed. Small errors (<5%, good) were found for peak speed and distances. This study supported the validity and reliability of this GPS model.

Keywords: training; circuit; team sports; velocity; coaching

Introduction

Team sports are characterized by an intermittent model where aerobic and anaerobic components are highly taxed (7,18,25). Athletes generally perform specific actions during official matches and training sessions including, high speed running and accelerations (35,40). It is well known that the correct evaluation of external load parameters is crucial for sports scientists (13,29,34). This information has a critical impact on daily basis decisions and periodization (24). Global Positioning Systems (GPS) are instrumentations utilized to quantify the external load parameters in team sports (6,10,16). GPS have a better time efficiency and greater practicality (e.g. allows for real-time feedback and less operator work) compared to video tracking systems during training sessions, and for such reasons GPS represent the most common technology for players' external load evaluation (4,12,17). GPS are used especially during training sessions, to collect and analyze kinematic data such as total distance covered, accelerations and sprints, as well as distance at high intensity (17,36,37). Across sports, high intensity speed running is associated with different speed bandings, therefore a univocal speed threshold does not exist (7,13).

GPS accuracy, validity and reliability have been commonly investigated in sports (5,16,27,32). The measures of validity explain the difference between the values recorded by GPS and the criterion measures, while reliability refers to the reproducibility of values of a test on repeat occasions (8,17,28). Several studies underlined that a higher sampling rate (10-15 Hz) provides a more valid and reliable measure of the athlete's movement demands compared to less sophisticated devices (1-5 Hz) (32). Despite such improvements, the validity and reliability of the most recent units decrease when tested in small distance tracks (sports specific circuits), high intensity change of directions (e.g. short shuttle runs), and during high-speed movements (e.g. peak speed)

(4,26,27,32). Previous evidence has also proved that large variability exists in the accuracy of different GPS brands, as well as variability observed between GPS units of the same model (16,27). Therefore, any GPS model should be validated independently and the results of a specific brand cannot be extended to others (1).

STATSports Viper units are devices widely used at national and international level (e.g. Premier league, Italian Serie A, etc.). Up to now, only one study has evaluated the validity of these GPS model (STATSports, Viper) (4), and has found an average error of 0.31 ± 0.55 m compared to the criterion measure during a 10-m short shuttle runs (distance bias = 2.53%). Moreover, GPS average speed was different compared to video analysis (25Hz) during short shuttle runs at different speed, with an average error that decreases as the distance increases (from 8.7 to 3.5% at 5 and 20-m, respectively) (4). However, this study presents some limitations due to the lack of a gold standard criterion instrument to evaluate peak speed, as well as distance was not evaluated during a sport specific circuit but only during linear short-shuttle runs (16). Moreover, no information about STATSsports reliability are reported in this study. Therefore, it is not possible to consider such information and the research on this device as exhaustive.

The validation process is a critical step for the application of this technology in sports and in research studies. Sports scientists and coaches need to know the limitation of such GPS model to better lead and organize their practice. Such information is paramount because sports scientists can utilize GPS data to manage player training load, recovery and subsequent training sessions (3,19). It is also fundamental to understand the validity and reliability of such GPS units to better compare the metrics during training sessions and among the players. Such interpretation and decisions can only be made when the reliability and validity of a GPS technology is well known. STATSports Viper unit technology is largely utilized in professional sports (e.g. Premier league, Italian Serie A), as well as for research purposes, therefore its validation can have critical implications for sports scientists and researchers. Therefore, the main purpose of this study is to assess the validity and reliability of STATSports Viper units by evaluating distance and peak-speed during sports-specific activities.

Methods

Subjects and research design

Twenty students (age 21 ± 2 years, weight 73 ± 5 kg, height 1.78 ± 0.04 m) were considered in this study (data recorded during 2017). The experimental protocol was in accordance with the Declaration of Helsinki for the study on human subjects. The Institutional Ethics Board of the University of Suffolk approved the experimental protocol.

Experimental protocol and data analysis.

GPS data collection were performed on an athletic track clear of large buildings to enhance satellite reception (38). GPS validity was evaluated by comparing the instantaneous values of speed (peak speed) determined with these devices and with those determined by a radar gun (Stalker ATS 2, 34.7 GHz, USA) during a 20-m sprint. Data were analyzed using the Stalker ATS Version 5.0.3.0 software. ATS II radar uses a high frequency radio waves and measures the change in the frequency after it bounces off a moving object (Doppler radar). Radar gun and laser devices are considered a gold standard instrument for evaluating peak speed (17,32,36). Stalker ATS validity and reliability has been previously reported (21). GPS accuracy for recording distance was evaluated using the criterion distance of a 400-m athletic track, as well as using a specific team sports circuit of 128.5-m that replicated the movement demands of team sports (performed on synthetic surface) and during a 20-m linear running (24). The validation of this circuit was reported in previous studies (9,16). The researchers explained to all subjects to remain in a standing position for 30 seconds, after their signal to start the trial. All subjects returned exactly to the starting point where they waited for another 30 seconds in a standing position. The start time for each trial was determined by the increase above zero on the velocity trace. Subjects completed two 400-m trials at a self-selected speed (jogging pace), 128.5-m trials (speed reported in figure 2b), 20-m linear running (jogging pace) and a 20-m sprint at maximum speed. Each subject was verbally instructed during each trial to perform the correct procedure. Every player performed a familiarization trial (week 1) before the beginning of the experimental period (week 2). 400-m, 128.5-m circuits, 20-m trial, and 20-m sprint were performed by the participant of this study (validity evaluation, week 2) and each trial was repeated with the same procedure (test-retest) a week later (reliability evaluation, week 3). Each session was performed in similar weather conditions (e.g. no rain or clouds). Validity and reliability procedure adopted in this study were previously utilized in literature and are considered appropriate to simulate movement patterns of sports in a standardized manner (24).

Figure 1 (a, b, and c) here.

The GPS units were turned on about 10-15 min before the beginning of the test; whilst the subjects were familiarized with the equipment, as well as the protocol procedures. During the experiments a GPS unit (10 Hz, Viper Units, STATSports, Ireland) was placed on the back of the subjects by means of a harness at the level of the chest. GPS Viper has the following characteristic: dimension 33 mm (wide) x 88 mm (high), weight 48 g, 10 Hz GPS, 100 Hz gyroscope, 100 Hz tri-axial accelerometer, and 100 Hz magnetometer. The same GPS unit were utilized for all participants to avoid inter-unit variability (a possible confounding factor). GPS data (speed and distance) recorded by the GPS were downloaded and further analyzed by the STATSport Viper Software (firmware 2.7.1.83). The number of satellites visualized by this unit, as well as the horizontal dilution of position are not reported by this GPS model and therefore, are not reported in this study.

Please, figure 2 and 3 (a and b) here.

Statistical analysis.

Data are presented as means ± SD. A Shapiro-Wilk test was performed for the evaluation of normality (assumption) for statistical distribution. Validity was assessed using the bias (%) between the known distance and the GPS (absolute error). Bias was interpreted as poor (>10%), moderate (5–10%), or good (5%) (23). Differences between GPS speed and criterion were reported as a mean of change with confidence intervals (CI 90%) (22). Paired t-test was used to compare the peak speeds recorded. Statistical significance was set at $p < 0.05$. Effect size (ES) was interpreted by Cohen as trivial <0.20, small 0.20–0.59, moderate 0.60–1.19, large 1.20–2.00, and very large >2.00 (15). Threshold values for benefit or harmful effect were evaluated based on the smallest worthwhile change (SWC) (0.2 multiplied by the between-subjects SD) (23). Hopkins's spread sheet (validity by simple linear regression) was used to evaluate criterion and GPS peak speed (23). Regression analysis was used to show the relationship between actual and measured peak speed. A correlation system from trivial (<0.1), small (0.1-0.3), moderate (0.3-05), large (0.5-07), very large (0.7-0.9), nearly perfect (0.9), to perfect (1.0) scores was used (23). The reliability (between the week 2 and week 3) was assessed using the typical error of measurement and expressed as percentage of coefficient of variation (CV). Statistical analysis was performed using SPSS (Statistics 20.0) for Mac OS X Yosemite.

Results

GPS distance covered in the 400-m trial, 128.5-m circuit and 20-m trial was 395 ± 10.7 m and 131.7 ± 1.5 m, 20.17 ± 0.28 m, respectively, with an absolute error of 7.9 ± 7.2 m and 3.48 ± 1.5 m, 0.25 ± 0.21 m, respectively. The bias in each trial was 1.99 ± 1.81%, 2.7 ± 1.2%, 1.26 ± 1.04%, respectively. Peak speed measured by the GPS was 26.3 ± 2.4 $Km{\cdot}h^{-1}$ and criterion was 26.1 ± 2.6 $Km{\cdot}h^{-1}$. Mean difference was -0.27 (-0.48; -0.53), p = 0.045, ES = 0.07 (trivial). The absolute error of the GPS was 0.4 ± 0.45 $km{\cdot}h^{-1}$ and the bias was 1.80 ± 1.93% (good). Correlation between

GPS and radar gun peaks speed ($r = 0.98$ CI (0.96; 0.99), $p < 0.001$) (nearly perfect). GPS reliability is reported in Table 1 as mean of change with CI 90% and CV. Test-retest parameters (distance covered in the 400-m trial, 128.5-m circuit, 20-m trial, and 20-m sprint and peak speed) recorded in week 3 were 397.8 ± 8.6 m, 131.2 ± 1.3 m, 20.31 ± 0.5 m and 26.1 ± 2.2 $km \cdot h^{-1}$. SWC of the with-in parameters (test-retest of distance covered in the 400-m trial, 128.5-m circuit, 20-m trial and peak speed) was 2.1 m, 0.3 m and 0.04 m, 0.44 $km \cdot h^{-1}$, respectively.

Table 1 here, please

Discussion

GPS is a technology commonly used to evaluate external load parameters (e.g. total distance, peak speed, etc.) in sports (1,2,7,10,13,30), therefore the validation process of this technology is crucial for scientific acknowledgment and credibility. Sports scientists and coaches need to know the limitation of such GPS model to better utilize and interpret the data recorded. The aim of this study was to assess the validity and reliability of STATSports Viper units by evaluating distance and peak speed during sports-specific activities. The major findings of this study were that GPS STATSports showed small bias (<5%, good) for peak speed (20-m) and distance (400-m linear running, 128.5-m circuit, 10-m linear running), therefore data reported in this study supported the validity of these GPS units. Moreover, this study reported high levels of reliability (CV), and a small mean of change (test-retest) in every variable (Table 1).

Literature shows that high intensity activities and sports specific movements (e.g. short sprints) are associated with a low level of GPS accuracy (10,11,33). However, this study did not find these limitations in the parameters analyzed. Scientific literature has revealed that sampling rate is a parameter closely associated with validity and reliability (17). Current GPS have a higher sampling frequency than previous GPS models (10 Hz and 5-1 Hz, respectively) on the market, therefore new GPS could report higher accuracy than previous models (4,14,24). The data recorded in the current study can be compared with only one study that analyzed the same GPS model used in this research (4). It was previously reported that Viper units underestimated speed and distance (20-m) with a bias of 3.5% and 2.53%, respectively. The results of the current study showed a lower bias in both the evaluations that was equivalent to 1.80% (sprint 20 m) for peak speed and 1.99%, 2.7% and 1.26%, for distance evaluated using a 400-m circuit (linear running), 128.5-m circuit (sports specific running), and 20-m linear running, respectively. The discrepancies between these two studies could be explained by considering the activity performed by the athletes (different circuits were utilized in the current study). In the previous study, subjects performed shuttle runs (with a 180-degree change of direction) on an athletic track at three different velocities: slow (2.2 $m \cdot s^{-1}$), moderate (3.2 $m \cdot s^{-1}$), and high (3.6 $m \cdot s^{-1}$) over the following distances: 5, 10, 15 and 20 m. Moreover, the main limitation of the previous study was associated with the criterion value considered that was not a gold standard (video analysis) (4). Both the studies showed that GPS STATSports units have a good level of accuracy (bias: <5%, good) in the measurement of distance and speed.

10 Hz Viper units utilized in this study showed low errors in total distance for circuit laps and peak speed. These results are supported by previous publications that showed general advantages of current 10 Hz technology (e.g. greater accuracy and reliability) compared with the previous 1-5 Hz units (16,24,30). In several previous studies, sprint speed was evaluated indirectly (e.g. correlation between time gates and average speed), thus the peak speeds were not directly measured with a criterion measurement (32). Contrariwise, this study presented a direct comparison with a gold standard criterion (for the first time for STATSports). The relationship ($r = 0.98$, nearly perfect) between radar gun peak speed and GPS peak speed during 20-m sprint, provided evidences to support the utilization of such GPS to assess sprint performance in team sports (31). However, sports scientists should be conscious that a statistical difference also exists between peak speed assessed using GPS and radar gun (mean difference = -0.27 km.h-1, $p = 0.045$, ES = .07). This new

evidence could offer several advantages to sports scientists that could integrate the evaluation of athletes' average speed using time gates with the evaluation of peak speed using GPS. Current GPS on the market seem able to evaluate peak speed with sufficient accuracy (24), therefore sports scientists could use such technology during athletes' evaluations.

This study reports innovative and practical implications regarding the reliability of the STATSports Viper units. It is not possible to compare this data with previous studies that evaluated the reliability of this same GPS units, however, it is possible to compare these data with other GPS models. In a recent study, the GPXE PRO (18Hz) and MinimaxX S4 (10Hz) were analyzed and reported a small bias (%) in each parameter considered (24). It was reported a bias in distance covered during 10-m sprinting (0.6 ± 1.6% and 2.5 ± 3.5%), 20-m sprinting (0.2 ±1.1 and 2.2 ± 2.2), 30-m sprinting (0.7 ± 0.8% and 1.2 ± 1.3), 129.6-m circuit (0.9 ± 0.4% and 2.0 ±0.8) and peak speed (0.6 ±1.1% and 1.4 ±1.1%), for GPXE PRO (18Hz) and MinimaxX S4 (10Hz), respectively (24). STATSports reliability data recorded in this study present small CV for 400-m trial, 20-m trial, 128.5-m circuit, and peak speed that are in line with the bias reported for GPXE PRO (18Hz), while are smaller than MinimaxX S4 (10Hz). The current GPS technology seems able to offer reliable data in different conditions such as distance covered during short and long linear activities (20-m trial and 400-m running) as well as during a sports specific circuit (128.5-m) (20,24,26,32).

This study presents four main limitations: firstly sport-specific movements were evaluated using a circuit and human error should be taken into consideration (e.g. movement away from the track). For instance, during the 400-m trial human error could have affected the results (397.8 ± 8.6 m). Studies that conduct trials with humans could present variability between the designs, therefore sports scientists and coaches should consider such limitations. Future studies could replicate our results to confirm the bias (%) reported in the current study using mechanical devices moving at known distances and speeds. Secondly, a recent review reports that sport-specific movement and peak speed could be evaluated using a VICON motion analysis system that can offer additional information of GPS validity (32). In this study, a radar gun was used to evaluate the peak speed during 20-m sprint, however this technology is not suitable to evaluate speed during sports specific movements that are not linear, therefore future studies could evaluate the GPS STATSports considering the inclusion of VICON motion analysis. Many team sports allow the use of GPS technology during official matches, however literature suggests that professional teams may still be cautious when GPS technology is utilized in such a context because stadium and spectators could affect GPS precision and reliability (32,39). Sports scientists should be conscious that data reported in this study were obtained in optimal conditions and cannot be extended to any other environment/conditions (e.g. stadium, poor weather condition). However, future studies could evaluate the same parameters inside a stadium to analyze their validity and reliability in such circumstances. Another limitation of this GPS technology is the inability to report the horizontal dilution of precision; therefore, the findings reported in this study need to be interpreted considering such a limitation (20,24,32). The last limitation could be associated with the number of GPS units utilized in this study that is not representative of the cohort of units that generally clubs utilized. Professional clubs can receive up to 50-80 units at a time, therefore sports scientists should be conscious of such limitation.

Practical applications

The evaluation of GPS STATSports units validity and reliability was a paramount step for its application in a sports context and for research purposes. Considering that such units are largely utilized in professional sports (e.g. Premier league, Italian Serie A), as well as for research purposes, this study offers innovative implications for sports scientists and researchers. The findings reported underline that distance and speed data reported by STATSports Viper units showed good levels of accuracy and reliability. Moreover, coaches could use such technology to better compare the metrics during training sessions and among the players, as well as to manage player training load, recovery and subsequent training sessions. However, sports scientists should be conscious that this GPS technology presents some errors (around 1-2%), therefore metric variations among players and training sections should be analyzed with these errors in mind. Future studies could be required to confirm our results.

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Figure 1a. 400-m athletic track

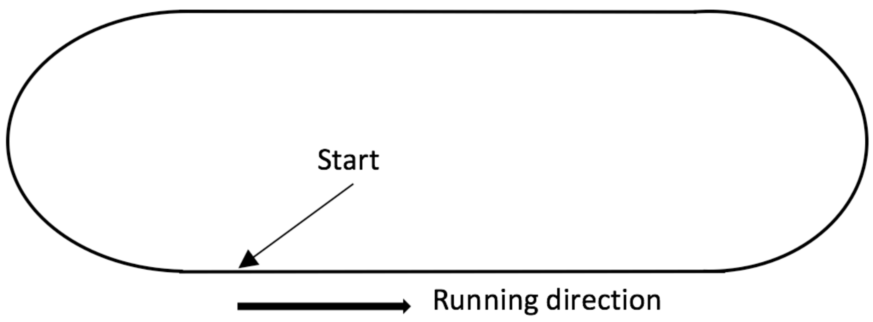

Figure 1b. Specific team sports circuit of 128.5-m

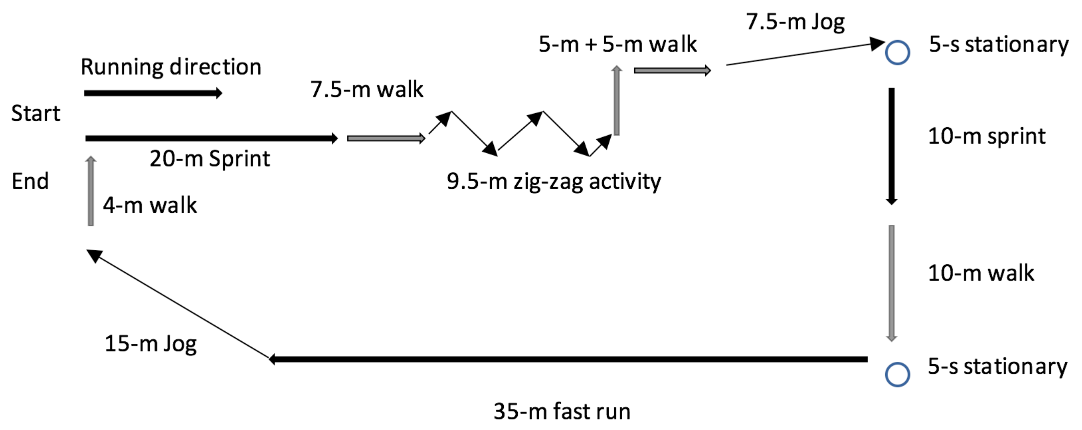

Figure 1c. 20-m sprint

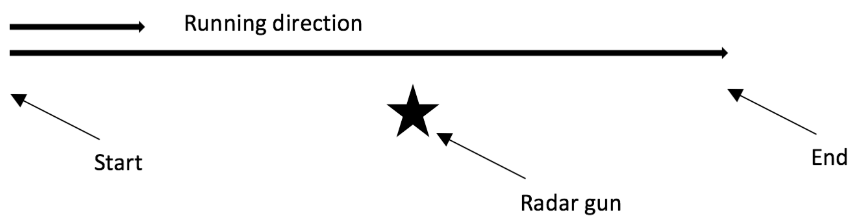

Figure 2. STATSports Viper 10 Hz