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Accuracy Assessment of a GPS Device for Maximum Sprint Speed

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ABSTRACT

International Journal of Exercise Science 13(4): 273-280, 2020. Global positioning system (GPS) technology can capture maximum sprint speed (MSS) using fewer resources than electronic timing gates (ETG). Yet, errors with GPS technology are typically 1.01 km·hr^{-1} for instantaneous velocity, potentially limiting GPS accuracy. The purpose of this study was to compare MSS values obtained from GPS technology to those obtained from ETG. The MSS of 24 female athletes was determined using two tests that both began with a 20-m fly-in followed by: 1) 80-m maximal sprint with ETG placed at the start line, 30 m, 60 m, and 80 m, and 2) 30-m maximal sprint with ETG placed every 10 m. Sprint speed was calculated from each timing segment, and the fastest segment for each test was used for the calculated MSS. MSS was also obtained using a GPS unit measuring at 10 Hz. Mean bias and mean absolute percent error (MAPE) of the GPS was lower for the 80-m test (0.09 ± 1.24 km·hr^{-1}, 3.5 ± 3.1%) than the 30-m test (1.58 ± 0.80 km·hr^{-1}, 5.5 ± 2.6%). Lin's concordance agreement was found to be poor for both tests. The equivalence test indicated that the GPS was equivalent for both short and long distances, $p < .05$, meaning the two results were within a 5% equivalence interval. The GPS devices were within the acceptable range of accuracy at short (10-m) and long (30-m) distances. These results can guide coaching staff regarding how to test their athlete's metrics and the reliability of those results.

KEY WORDS: Velocity, sprinting, global positioning system, team sports, athlete monitoring, electronic timing gate (ETG)

INTRODUCTION

Global positioning system (GPS) technology has gained popularity in the athletic monitoring field. These devices are used to give valuable insight into the external load demanded of athletes (20). They also have the ability to collect data on training metrics including total distance run, maximum velocity reached, accelerations, decelerations, and a breakdown of how far the athlete traveled at various velocities (20). The accuracy of these devices varies with the type of sport being monitored, measurement frequency of the device, and distance measured (1). Maximum sprint speed (MSS) is one metric obtained using GPS. MSS is typically measured at the beginning of training seasons to help assess sprint and high-intensity efforts during game play and training. Most practitioners measure MSS using electronic timing gates (ETG) and calculate MSS for each athlete by hand. These timing gates are electronic transmitters set up at various distances along a linear path for athletes to run by in an attempt to reach their maximum velocity. Each athlete wears a chip connected to a belt or waistband so as to mark the time at which they pass each transmitter. The athlete's time is transmitted to an application from the transmitter. These systems are regularly used in track and other sports to measure athletes' speed. GPS technology offers an alternative way of collecting these data that could save time and require fewer testing administrators and resources.

Accuracy of GPS monitoring devices is crucial when measuring individual athlete metrics. Incorrect data can negatively impact the goals of training staff and hinder the conditioning progress of the team. When GPS devices inaccurately record an athlete's maximum velocity, distance run, accelerations, decelerations, and the distance traveled at various velocities, it gives coaches a limited view of how their athletes are performing. This inaccurate view of a team's performance level has the potential to give coaches a false security about the team's performance or can lead coaches to over work their athletes. Studies have investigated the accuracy and reliability of GPS monitoring devices in various ways and in numerous sports (2, 5, 8, 19). Previous research showed that the 4 Hz VX Sport GPS unit had a typical error for maximum speed of 0.75 ± 0.26 km·hr^{-1} (13), and a typical error of estimate for peak acceleration to be 3.7% for 10-m sprint time (3). Buchheit et al. also showed a 1.2% mean bias and 3.4% typical error of estimate for peak velocity during a 40-m sprint with the 4 Hz VX Sport device with youth male soccer players (3). A study on 10-Hz GPS STATSport devices found that the devices were accurate when running in a linear path; however Gray et al. found that 10-Hz GPS accuracy decreased as speed increased, making the testing of these devices all that more pertinent (8). Despite their decreased accuracy with increased speed, other research suggests that 10-Hz GPS seem to be the most reliable devices available (2, 6, 17).

Most published studies on GPS monitoring of MSS assess elite male athletes, limiting their applicability to female collegiate athletes (5). Thus, more research is needed to determine the accuracy of 10-Hz GPS monitoring devices when measuring sprinting for female collegiate athletes. Additionally, further research on the accuracy of GPS monitoring of MSS could better inform coaching staff of the limitations of GPS technology in metric data collection and could provide external load analysis that is sport-specific. If effective in capturing accurate MSS data, GPS monitoring could also save coaches valuable time when testing their athletes and negate the need for additional testing administrators and equipment. The purpose of this study was to compare the MSS values obtained from GPS technology measuring at 10 Hz to those obtained from ETG for long (30 m) and short (10 m) distances.

METHODS

Participants

This study assessed the concurrent validity of the VX Sport GPS tracker for MSS in female collegiate lacrosse players. *A priori* sample size calculations indicated that 14 participants were needed to achieve 80% power (3). Participants included 24 Division I female lacrosse players (19.7 ± 1.2 years 166.4 ± 5.9 cm, 64.8 ± 6.5 kg). All players were uninjured and eligible for participation at the time of testing. Players were excluded for the study if they were under 18 years of age or were injured and unable to complete the sprint task. Each participant completed an institutional review board-approved informed consent and was given the opportunity to ask questions about the study prior to participation. This research was carried out fully in accordance to the ethical standards of the *International Journal of Exercise Science* (15).

Protocol

In August of 2018 (offseason) and January of 2019 (preseason), athletes completed three maximal sprint efforts to determine MSS. For each trial, MSS was concurrently measured via the VX Sport GPS tracker (Wellington, New Zealand) and an ETG system (Freelap USA, Pleasanton, CA). For the duration of this paper the ETG results will be referred to as the calculated MSS while the GPS results will be referred to as the VX Sport MSS. Each participant was assigned one wearable VX Sport GPS tracker provided by the researcher and wore the same device throughout the study for consistency. Each GPS device was identical but attached to a personalized vest tailored to fit the participant. All participants were instructed to wear the GPS devices attached to their VX vests the same way and kept the devices and vests on throughout the duration of the study. The Freelap system has been shown to be accurate within 2/100 of a second (7). ETGs have been used as the criterion measure for speed in previous literature, suggesting this is valid and reliable method of evaluating speed (10-12, 16). All trials included a 20 meter fly-in sprint to omit the time it took to reach the maximum sprint speed, and to align with previous literature for evaluating speed accuracy in GPS devices (11). Configurations of each sprint and ETGs are shown in Figure 1. On the first test date, athletes sprinted the 20-m fly-in and subsequent 80-m, with ETGs placed at the start line, 30 m, 60 m, and 80 m. On the second test date, athletes sprinted the 20-m fly and subsequent 30-m, with ETGs placed every 10 m. After each completed trial, athletes walked back to the start line followed by a timed rest of greater than 90 seconds to ensure adequate recovery. A separate timer was used by a test administrator to time each participant's rest time as they were not allowed to begin the next test until at least 90 seconds had passed. After 90 seconds the participants were told to begin the next test at the researcher's command. Depending on the speed of each participant as they ran, some participants had a rest time of greater than 90 seconds as they waited for their next test to begin. Thus, the approximate work-to-rest ratio was 1 to 6, exceeding the guidelines of 1 to 5 provided by the National Strength and Conditioning Association (9).

MSS was calculated using the fastest segment time recorded of the three trials. Two MSS values were calculated for each athlete: one using the fastest segment from the 80-m trial and one for the fastest segment using the 30-m trial. The VX Sport GPS device collected data at a frequency of 10 Hz. Data were uploaded to VX Sport software and trimmed and split to solely focus on the MSS assessment period. The fastest velocity measured during the MSS testing time was recorded as the VX Sport MSS.

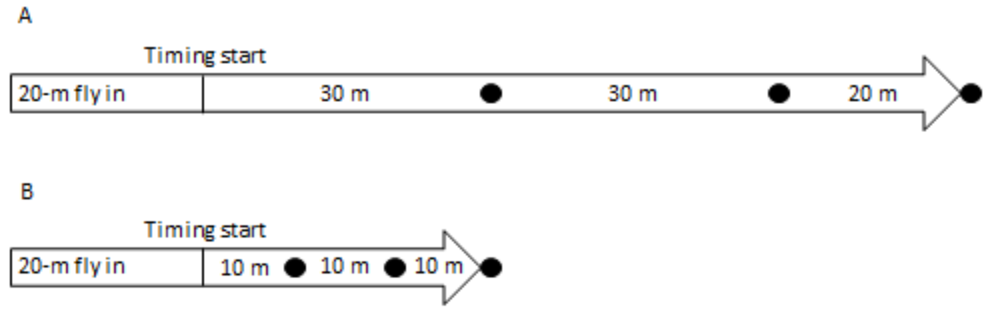

Figure 1. Schematic of the A) 80-m and B) 30-m maximum sprint speed trial. The black dots represent where electronic timing gates were placed and segment distances are indicated.

Statistical Analysis

Calculated MSS and GPS MSS were compared using mean bias, mean absolute percent error (MAPE), Lin's concordance correlation coefficient, equivalence testing, and Bland-Altman analysis. Based upon previous GPS research, a MAPE within 5% was deemed as acceptable (4, 6). Lin's concordance agreement and 95% confidence intervals (95% CI) were calculated and interpreted as follows: < 0.90 was poor, 0.90 to 0.95 was moderate, 0.95 to 0.99 was substantial, and > 0.99 was almost perfect (13). Two one-sided tests (TOST) of equivalence were used to determine if the difference between the two mean MSS were within a 5% equivalence interval. An alpha level of 0.05 was used to determine statistical significance. Bland-Altman analyses were also used to compare the calculated and VX Sport MSS values. All analyses were conducted in Microsoft Excel (Redmond, WA).

RESULTS

The overall results based on the equivalence tests for the VX GPS and manually calculated MSS times with the ETG devices rendered the two methods of MSS calculation within a 5% interval. These results support the 10 Hz GPS devices accuracy when measuring MSS. For the 80-m test day, the calculated MSS was 25.57 ± 1.46 km·hr^{-1}, while the VX Sport MSS was 25.48 ± 3.38 km·hr^{-1}, creating a mean bias of 0.09 ± 1.24 km·hr^{-1} and a MAPE of 3.5 ± 3.1%. MSS was determined using the first 30-m segment for 96% of the athletes; one athlete's MSS was determined in the final 20-m segment. For the 30-m test day, the calculated MSS was 26.69 ± 1.26 km·hr^{-1}, while the VX Sport MSS was 28.27 ± 1.65 km·hr^{-1}, creating a mean bias of 1.58 ± 0.80 km·hr^{-1} and a MAPE of 5.5 ± 2.6%. MSS was determined using the first 10-m segment for 50% of the athletes, the second 10-m segment for 29% of the athletes, and the final 10-m segment for 21% of the athletes. The Bland-Altman plots of the two days (Figure 2) show mean bias and limits of agreement. The Lin's concordance agreement was found to be poor for both tests as the results did not fall within the range of acceptable Lin's concordance range: 80-m test, ρ_c = .891 (.776, .948), and 30-m test, ρ_c = 0.808 (0.660, 0.896). The equivalence test rendered that the results from the two tests were equivalent (80-m test: p < .001; 30-m test, p = .032), meaning the two results were within a 5% equivalence interval.

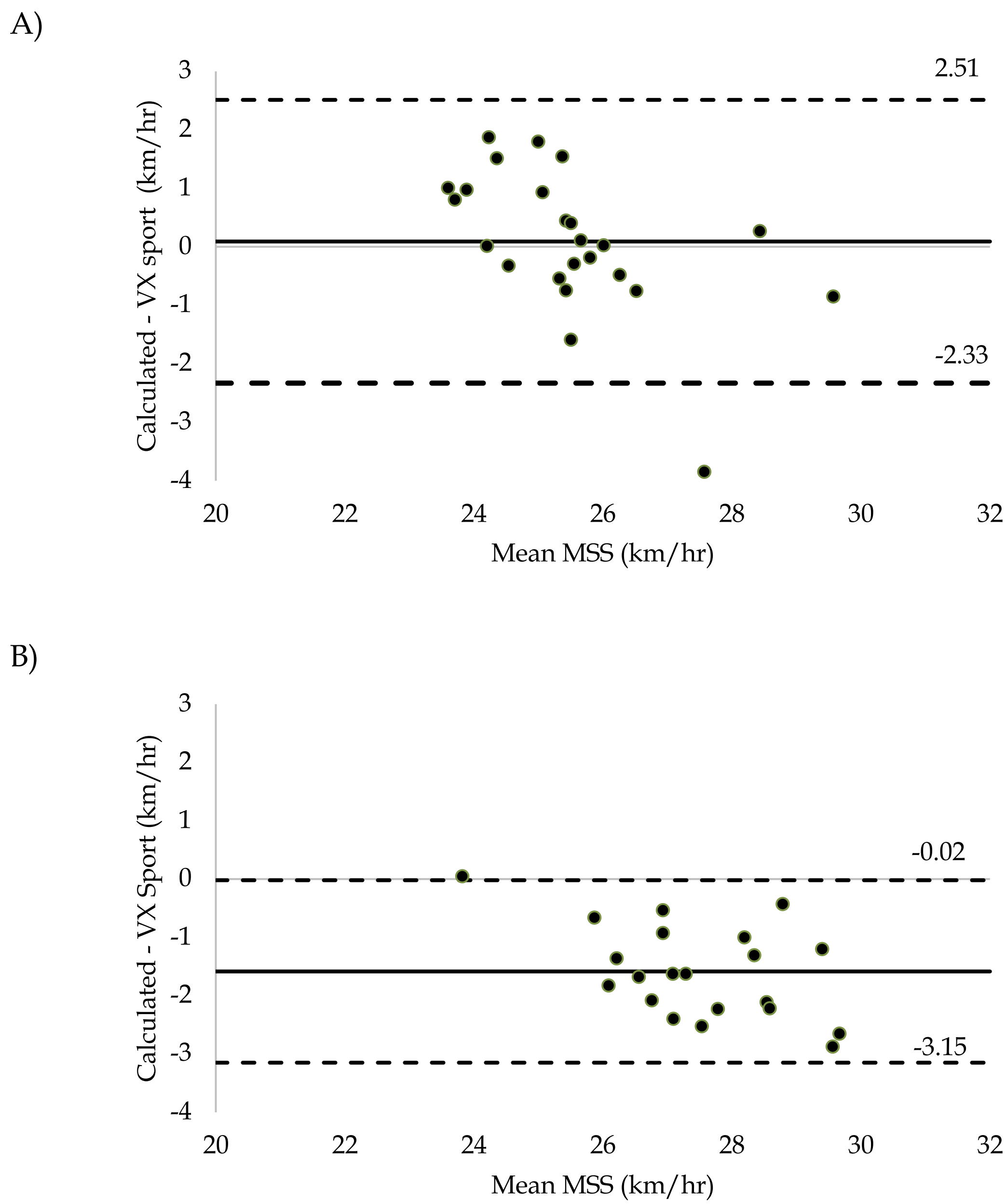

Figure 2. Bland-Altman plot of the A) 80-m and B) 30-m maximum sprint speed trials. The mean bias value is shown with the bold line and the limits of agreement are shown with the dashed lines.

DISCUSSION

The aim of this study was to determine the accuracy of the 10Hz VX Sport GPS devices for measuring MSS compared to measuring MSS using timing gates. Though the statistical analysis showed poor concordance between the two methods (with the 80-m test very close to moderate), the equivalence tests indicated that the two methods were equivalent within a 5% interval. According to the latter criterion, the 10 Hz GPS device was found to be accurate when measuring MSS. The smaller segments of 10-m used in the 30-m sprint test showed higher error (MAPE

5.5%) than the larger segments (30-m) utilized in the 80 m sprint test (MAPE 3.5%). While both results meet criteria for accuracy, there is a decrease in precision with shorter segments. This is supported by the concordance results as well with a lower correlation value for the shorter distance sprint.

The results of the present study are similar to the previous literature with VX Sport GPS devices, with similar typical error for peak velocity (3, 13). The previous literature used a device measuring at 4 Hz, whereas the present study measured at a frequency of 10 Hz. Thus, the increased measurement rate did not seem to improve the accuracy of the VX Sport device at the longer 30-m distance. Unfortunately, the previous literature is limited in peak velocity assessments at shorter distances of 10 m. However, a 10 Hz GPS device has been shown to accurately measure peak speed during a 15-m sprint with a moving start (18).

Data from the present study were all collected using a linear maximum sprint test which is useful and appropriate for measuring maximum sprint speed. However, linear sprinting is not a common movement in many team-based sports, so these data do not translate to agile movements. Previous literature has indicated that a 10 Hz GPS wearable device used a different measure criterion during a simulated team sport circuit, and that the device tended to overestimate peak speed during these bouts (11). The VX Sport GPS device—measuring at 4 Hz—was accurate in measuring speed during an agility course (3). Further research on the accuracy of the 10 Hz VX Sport GPS device is needed for measuring agility and on-field athlete movements.

One limitation for this study is that we did not split the VX Sport data for each sprint trial for MSS comparison per trial. Further we utilized short (10-m) and long (30-m) sprint segments to evaluate accuracy, but for some sports 30 m is not a long sprint segment. Thus, further assessment with varying sprint segments of 20 to 80 m may be useful.

Advancements in athlete monitoring methods can help efficiently improve team and individual athlete performance. Although research is not prevalent for many sports, existing literature suggests that GPS technology can be effective when used properly (2-6). This study demonstrated that 10Hz VX Sport GPS devices can be used to effectively measure MSS testing in female collegiate athletes, with greater accuracy over longer distances. The results of the present study address the research gap in monitoring of female collegiate lacrosse players, and findings suggest that GPS monitoring has the potential to help coaching staff save time and reduce personnel needed for MSS testing in this population when compared to the sole use of ETG which has been shown to be more time consuming.

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