Evaluation of Athlete Monitoring Technologies for Measurement of Controlled High Intensity (HI) Activity

25th April 2013

Background & Objectives

- Physical performance in elite Football and Rugby is closely monitored during matches and training with a principle focus on high intensity/speed distance covered and quantification of accelerations and decelerations.
- High-intensity running in football matches is generally considered to be the most important measurement for physical match performance *(Bangsbo, Mohr, & Krustrup, 2006; Drust, Atkinson, & Reilly, 2007).*
- GPS enabled tracking devices have been validated extensively over recent years and *Aughey (2011)* provides a comprehensive summary. However some doubts remain over the validity of GPS for measuring short duration, high speed activity *(Edgecomb & Norton, 2006, Barbero-Álvarez et al, 2009).*
- Sample rates for commercially available GPS units are increasing in frequency and research studies suggests that increased sample rates improve measurement accuracy *(Randers et al, 2010, Varley et al., 2011),* however the studies also acknowledge that these improvements could also be due to more advanced technology.

Objectives

- This study will analyse physical output data (instantaneous speed and acceleration/deceleration) from the Prozone system and a range of other monitoring technologies when measuring a series of controlled High Intensity (HI) activities.
- A further objective is to evaluate the measurement accuracy of a range of different GPS monitoring devices, assess correlations with controlled speed measurement and identify which GPS device(s) could be best aligned with Prozone for physical output data synergy.

Acknowledgments

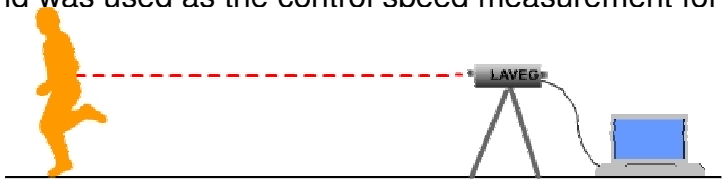
- Thanks to Dr. Phil Graham Smith and Paul Jones from **Salford University** for their support with LAVEG data capture and to Michael Clarkson from **Leeds Metropolitan University** for his support with the data analysis.

Test Environment

- Testing was conducted at the John Charles Center for Sport (JCCS), Leeds, UK.
- The Athletics stadium was chosen specifically in order to:
  - i) Permit the installation of the Prozone tracking cameras at a height >16m from ground level
  - ii) Provide an open environment for optimal GPS signal reception

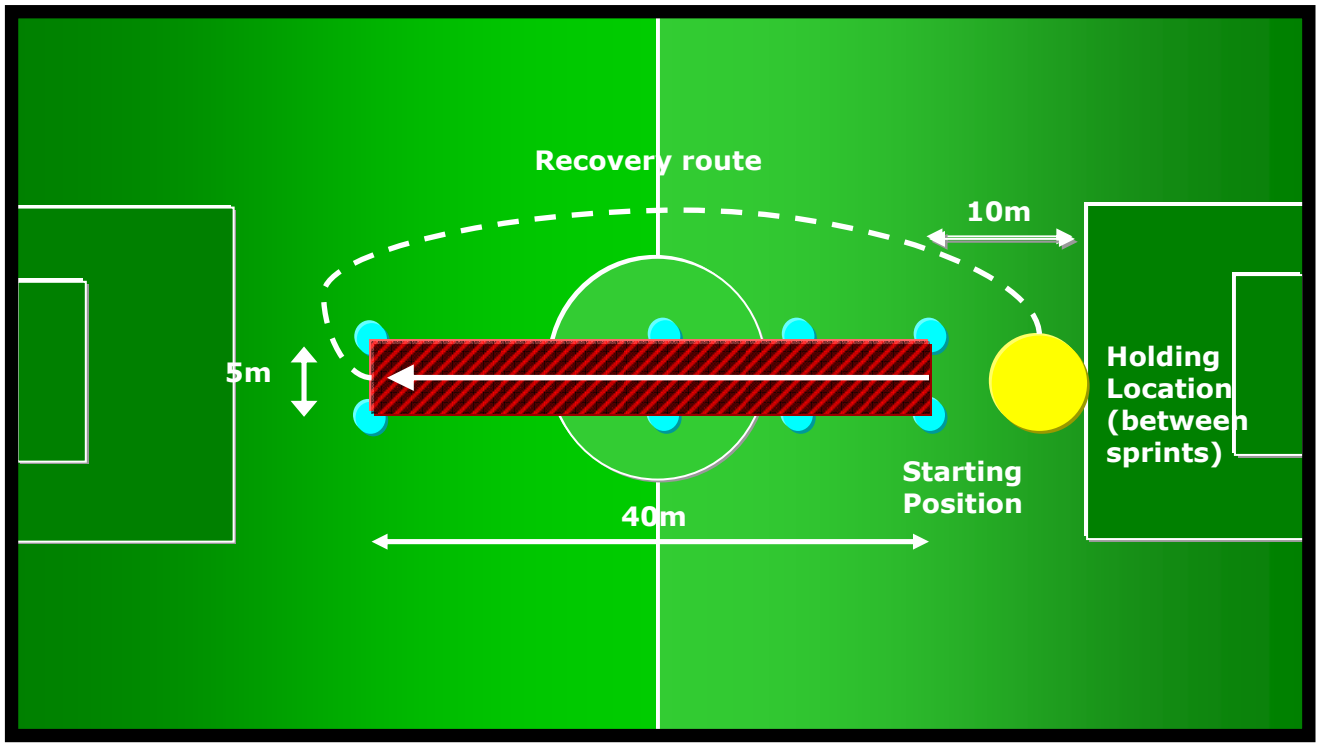
Methodology

- A single male test subject was selected with a capability to perform repeated high intensity activities and attain top speed measurements consistent with elite football players
- At the time of the test, the subject was aged 23 years, 4 months and 1.80m in height, 85 kg in weight
- The subject was instructed to perform a series of pre-defined runs over a distance of 40m in the center of the pitch:
  - i) 3 x linear maximum speed run from a stationary start
  - ii) 3 x linear acceleration then sharp deceleration
  - iii) 3 x linear 10m moderate jog from stationary start, then 30m acceleration to maximum speed
- Recovery time between each individual activity was c180 secs and the session duration was 60 mins
- Optical tracking cameras were located at the top of the main stand and recorded the entire session for digital image processing post activity
- A laser measurement device (LAVEG) was setup to record instantaneous speed during all HI activities. The LAVEG system samples at 50Hz and was used as the control speed measurement for comparison purposes.



- Cones were used to mark the 40m test area and timing gates were employed to measure 10m sprint intervals

Test Protocol Overview



Test 1

Explosive Sprint

Acceleration to maximum speed from a stationary start over 40m, sustain speed and run through gate (x3)

Test 2

Variable Sprint

From a stationary start, 10m accel/decel to stationary, 10m accel/decel to stationary, 20m acceleration to maximum speed and run through final gate (x3)

Test 3

Leading Sprint

10m moderate jog from stationary start, 30m acceleration to maximum speed and run through final gate (x3)

Subject Instrumentation

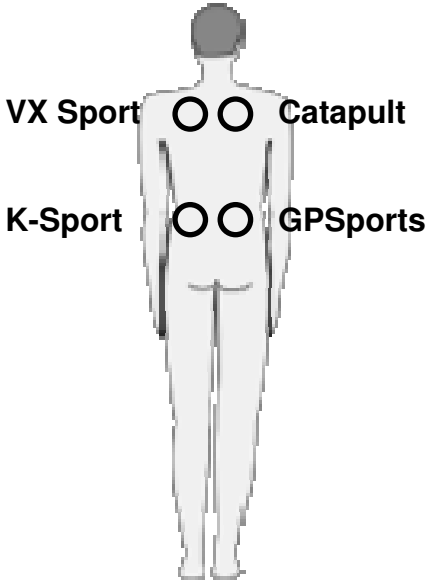
- The subject wore a specially modified vest containing 4 separate GPS tracking devices:
  - i) Catapult: MinimaxX s4
  - ii) GPSports: SPI Pro X II
  - iii) K-Sport: K-GPS
  - iv) VX Sport: VX Log 330a

- In addition, the subject also wore adidas F50 football boots containing the MiCoach Speed Cell (accelerometer)

4 GPS devices securely located on the subjects back (units embedded in pouches sewn into a compression garment)

LAVEG instantaneous speed measurement

Accelerometer within left football boot



Data Collection

- Instantaneous speed from the Catapult Minmax s4 system was provided every 0.1 seconds
  - GPS chip sample rate was 10 Hz
  - Data extracted from the Catapult Sprint software (5.0.6)
- Instantaneous speed from the GPSports system was provided every 0.067 seconds
  - GPS chip sample rate was 5 Hz
  - Data extracted from Athlete Management System (AMS) software
- Instantaneous speed from the K-Sport system was provided every 0.1 seconds
  - GPS chip sample rate was 10 Hz
  - Data extracted from K-Fitness software (1.00.055)
- Instantaneous speed from the VX Sport system was provided every 0.25 seconds
  - GPS chip sample rate was 4 Hz
  - Data extracted from VX View software
- Instantaneous speed from the LAVEG system was provided every 0.02 seconds
  - Laser measurement sample rate was 50 Hz
- Instantaneous speed from the Prozone system was provided every 0.1 seconds
  - Optical digitising sample rate was 10 Hz
  - Data extracted directly from Prozone production software

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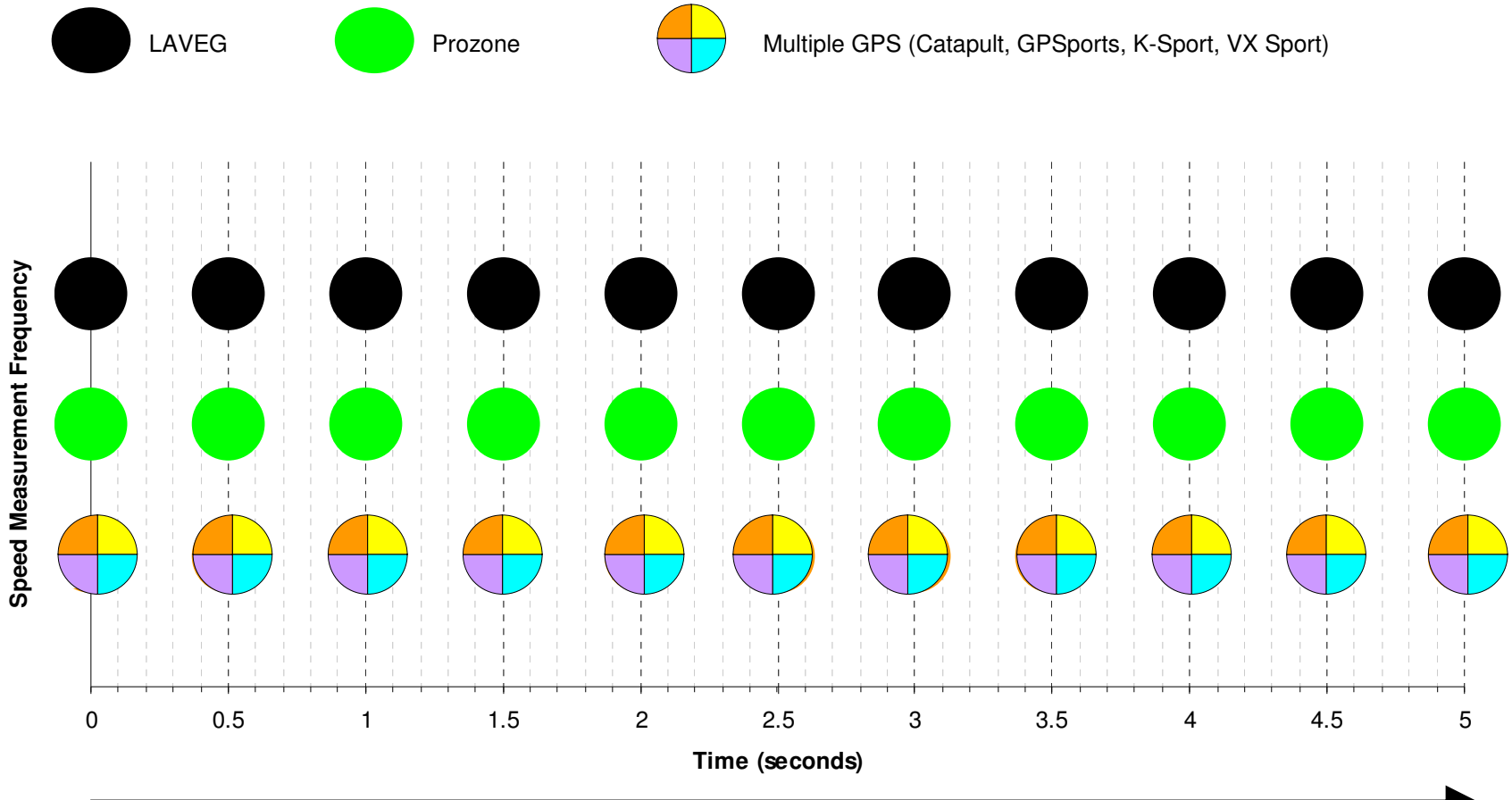
Data Capture

Physical Data Analysis

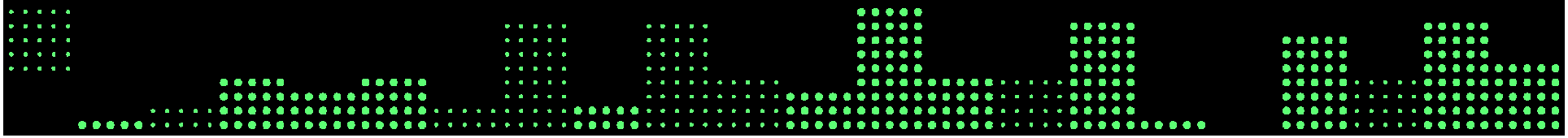
Sample rate for instantaneous speed measurement varied across the different capture technologies (4.0 hz to 50 hz)

For data analysis consistent with Prozone outputs, we used individual speeds and accelerations reported at **fixed** 0.5 second intervals relative to the start of each test activity, as illustrated in the diagram below. (S = unique speed/accel measurement)



Speed Measurement

Results & Analysis



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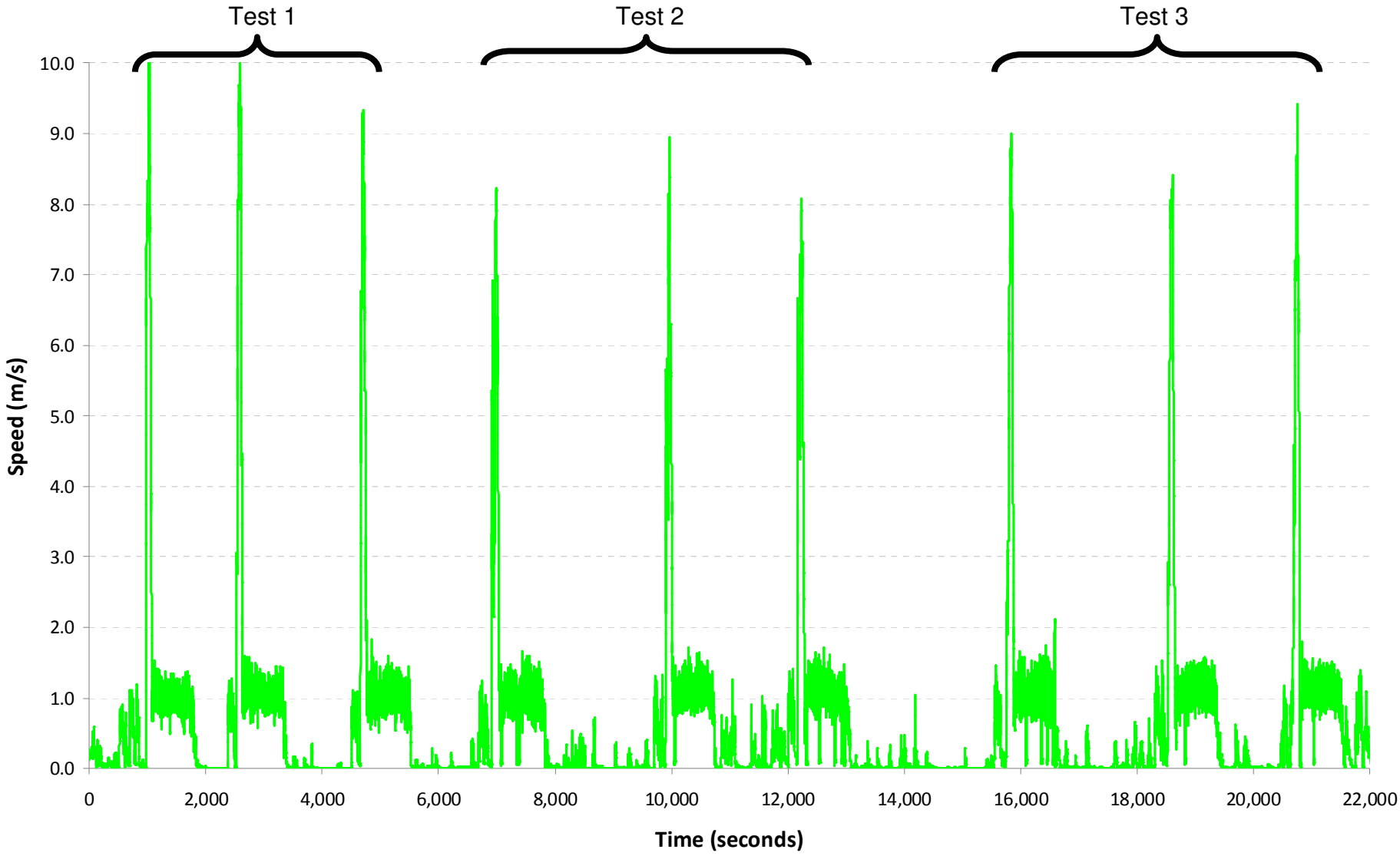
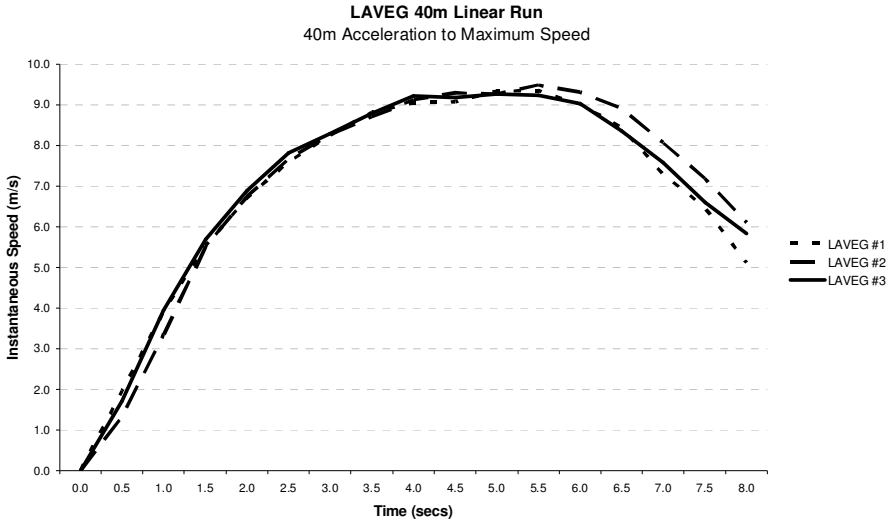
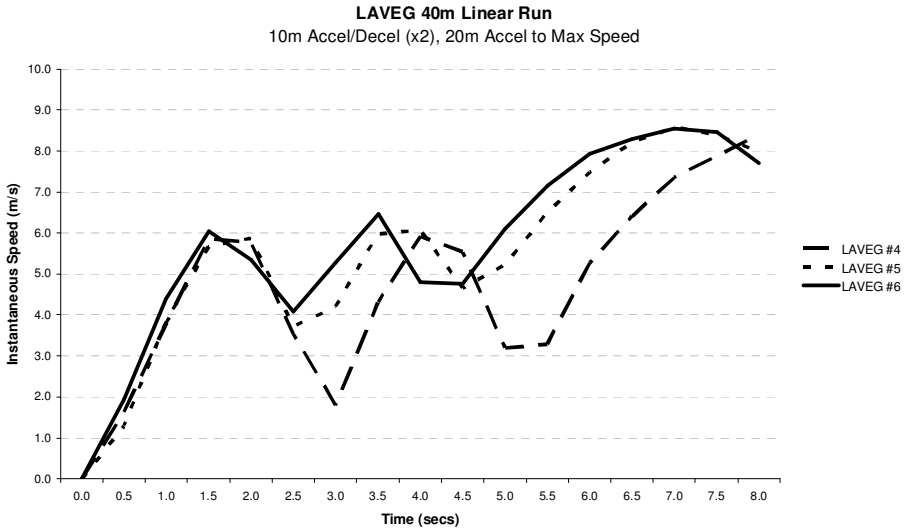
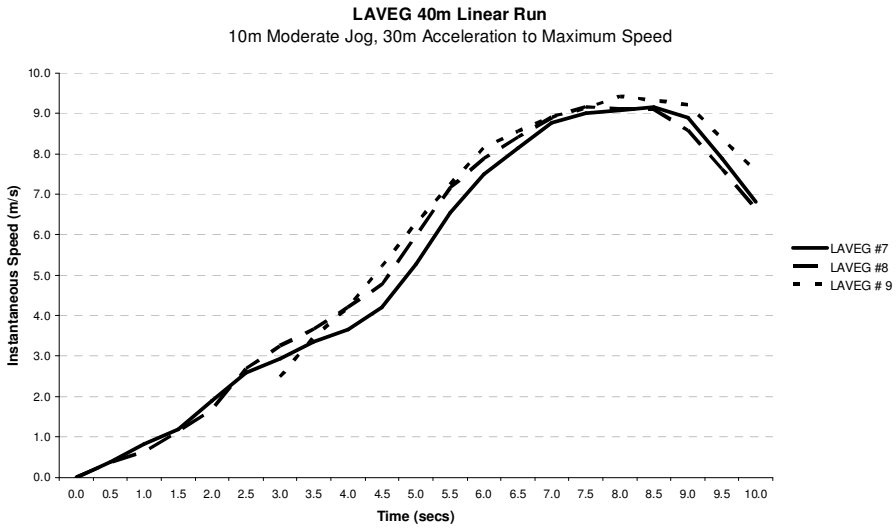
Session Overview



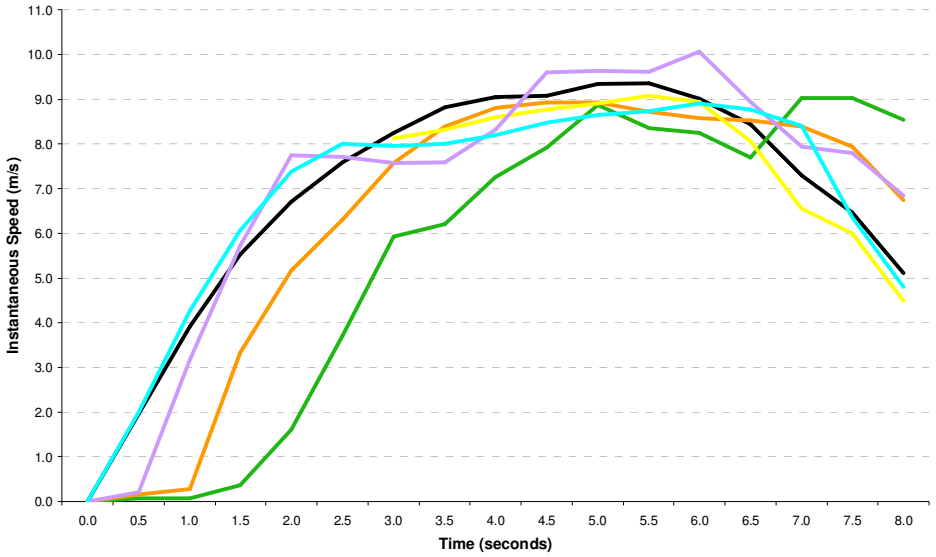
Tests 1-3: LAVEG Speed Profiles

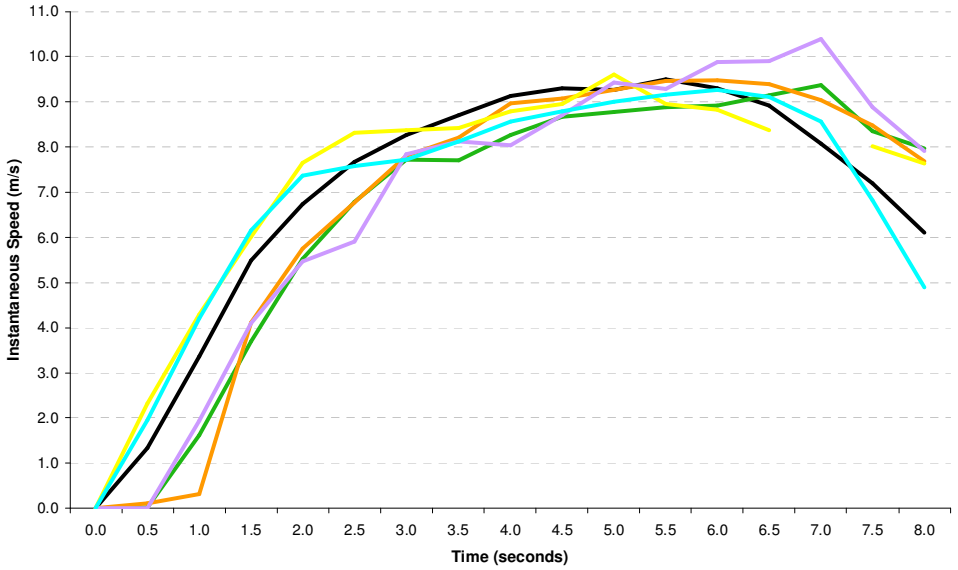


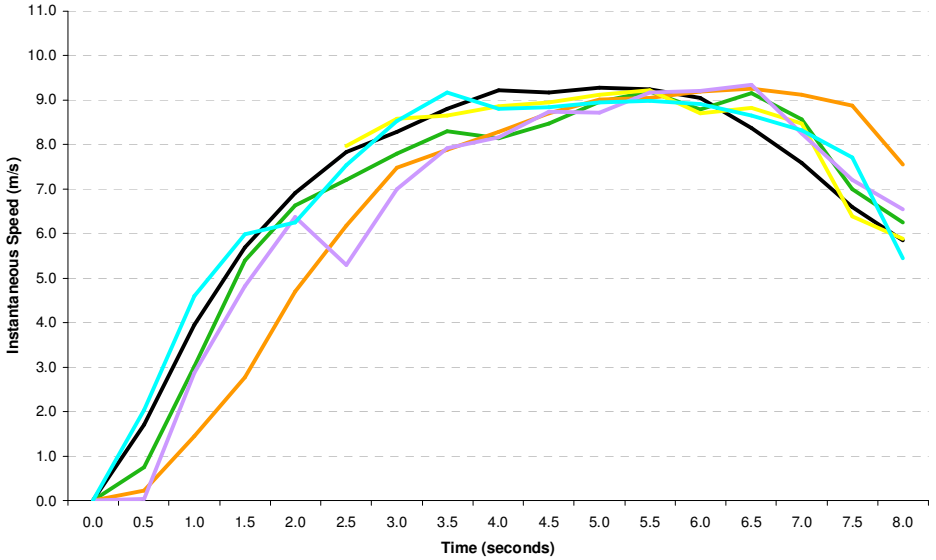




Test 1: Explosive Sprint Speed Profiles







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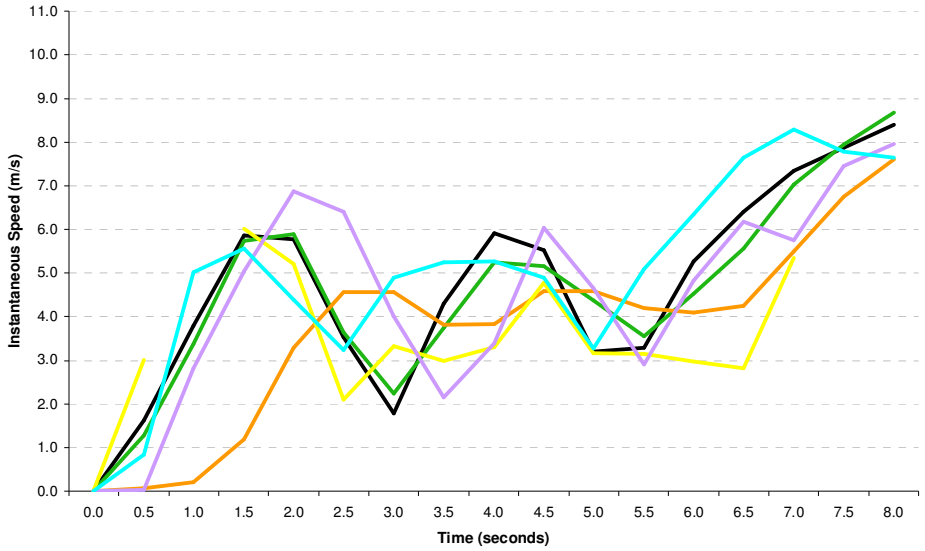
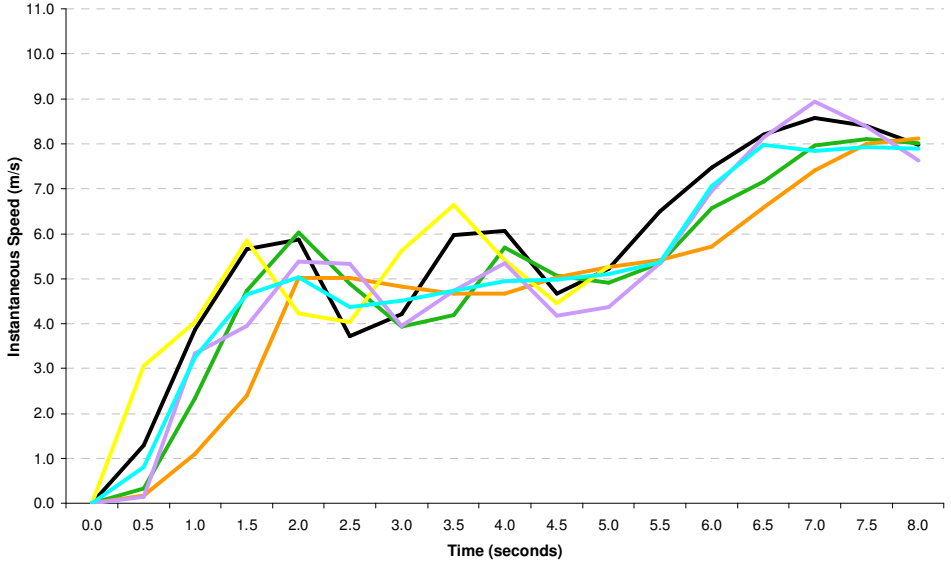
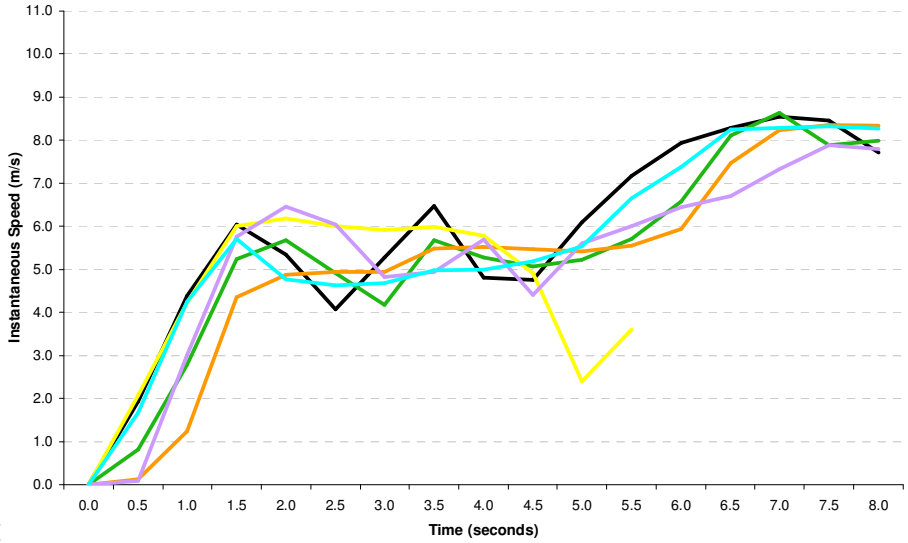
Test 1; Explosive Sprint

Acceleration to maximum speed from a stationary start over 40m, sustain speed and run through gate **(x3)**

Test 2: Variable Sprint Speed Profiles







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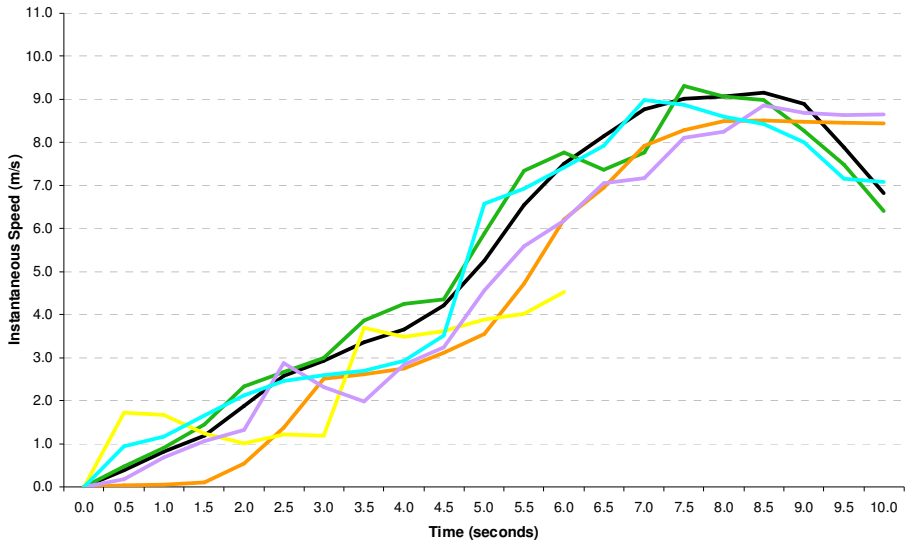
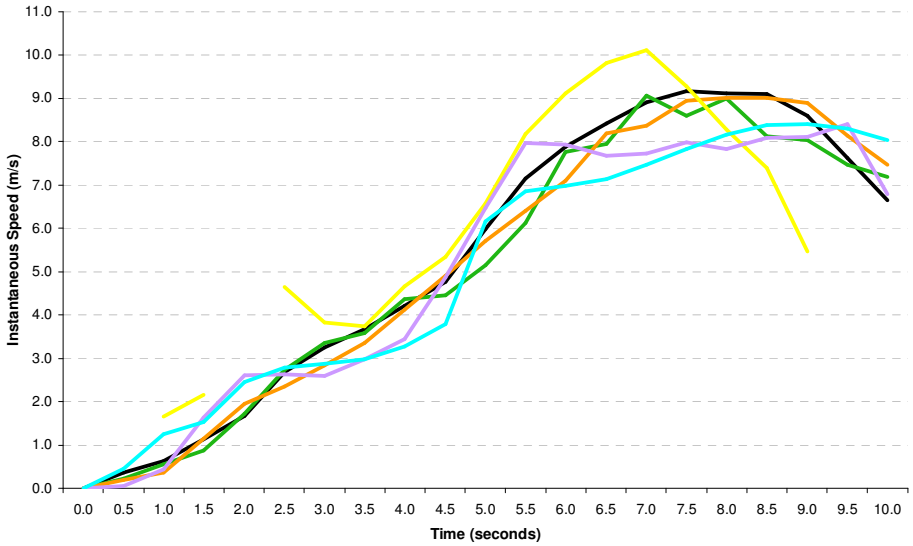
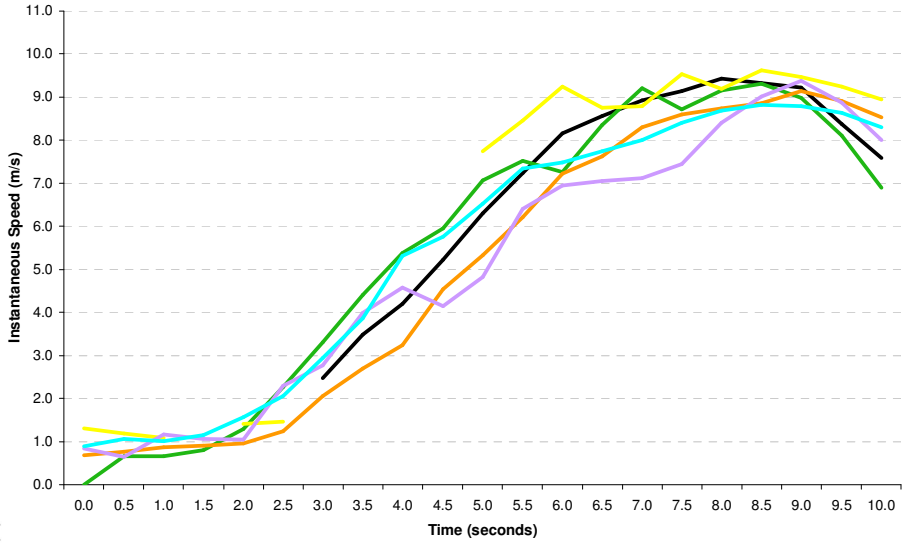
Test 2: Variable Sprint

From a stationary start, 10m accel/decel to stationary, 10m accel/decel to stationary, 20m acceleration to maximum speed and run through final gate **(x3)**

Test 3: Leading Sprint Speed Profiles







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Test 3; Leading Sprint

10m moderate jog from stationary start, 30m acceleration to maximum speed and run through final gate **(x3)**

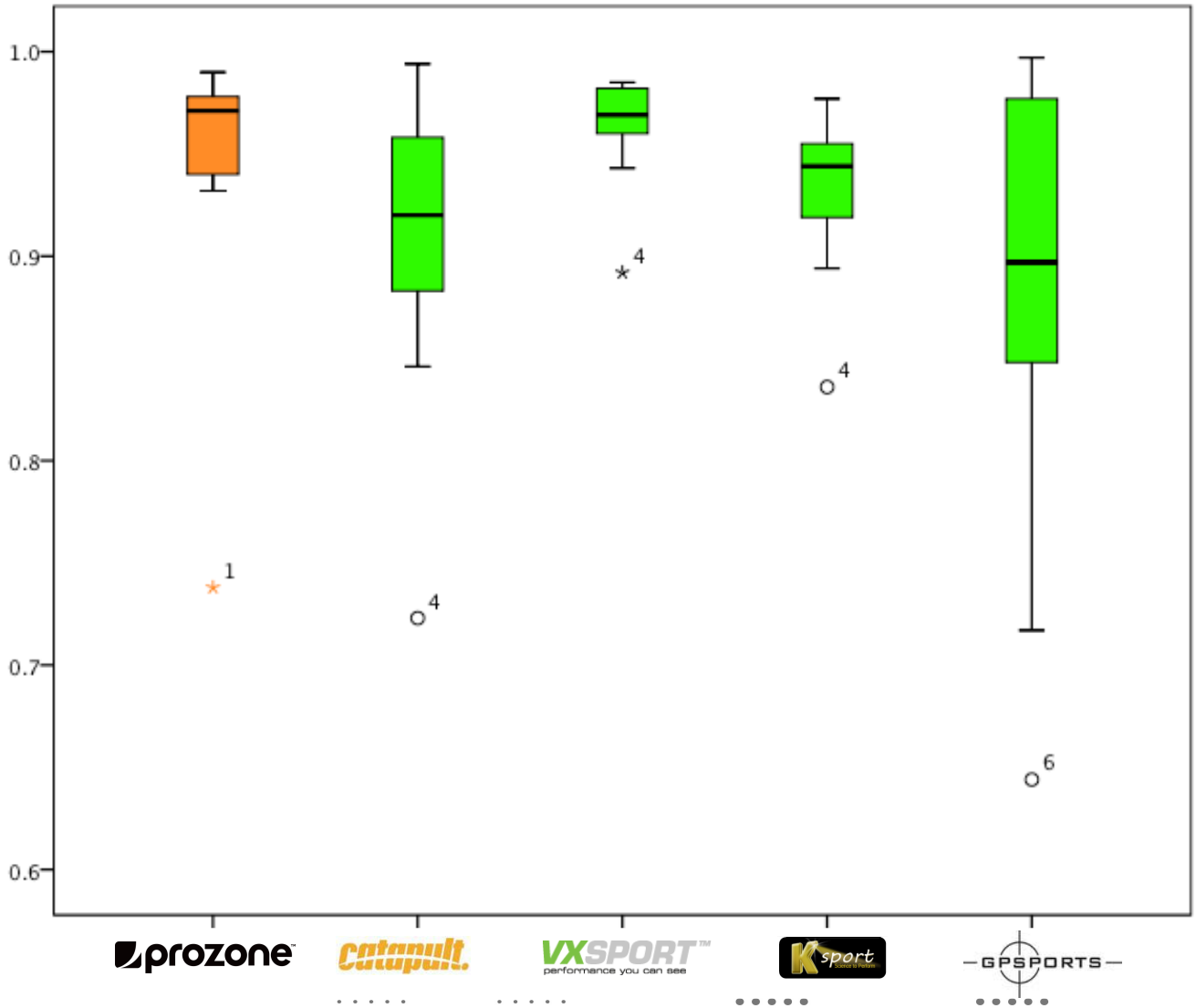
Speed Correlation vs LAVEG

Pearson's correlation coefficient calculated from speed measurement profiles using SPSS software.

		prozone	catapult	VXSPORT	K sport	GPSPORTS
40m Explosive Sprint	Sprint #1	0.738	0.920	0.979	0.955	0.997
	Sprint #2	0.940	0.940	0.982	0.921	0.977
	Sprint #3	0.978	0.883	0.985	0.944	0.991
40m Variable Sprint	Sprint #4	0.978	0.723	0.892	0.836	0.717
	Sprint #5	0.932	0.846	0.960	0.953	0.897
	Sprint #6	0.944	0.896	0.969	0.894	0.644
40m Leading Sprint	Sprint #7	0.990	0.958	0.983	0.957	0.869
	Sprint #8	0.987	0.977	0.943	0.977	0.917
	Sprint#9	0.971	0.994	0.965	0.919	0.848
	Average:	**0.940**	**0.904**	**0.962**	**0.928**	**0.873**

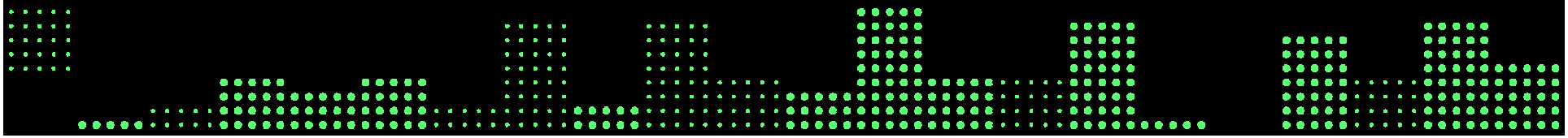
Speed Correlation vs LAVEG

Pearson's correlation coefficient calculated from speed measurement profiles using Minitab software.

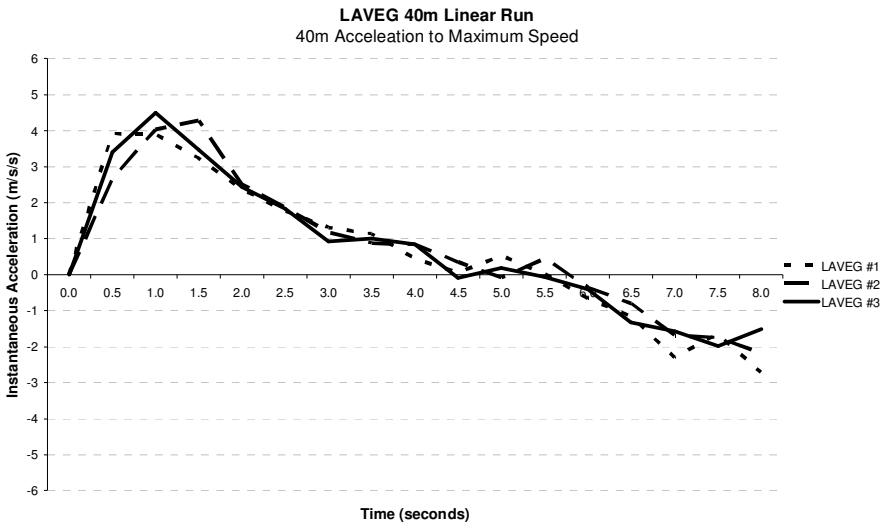


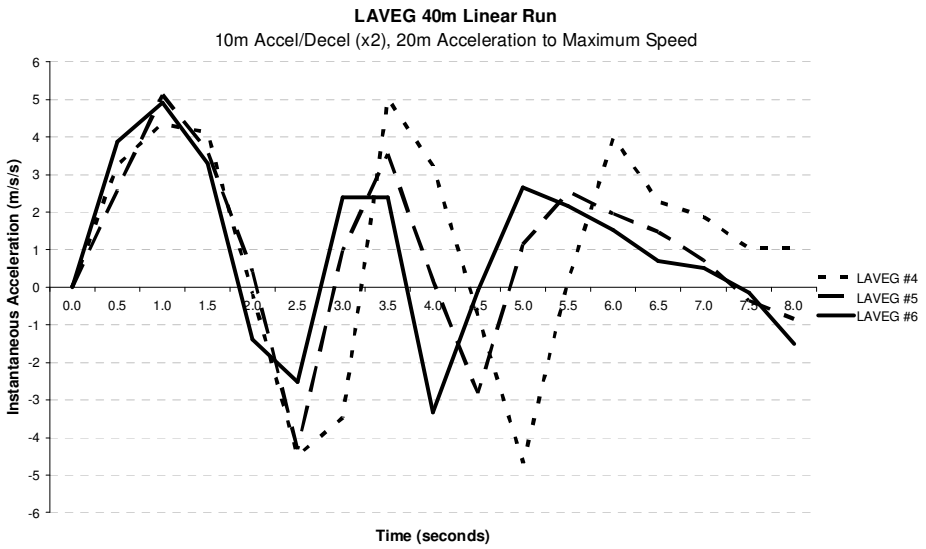
Acceleration/Deceleration Measurements

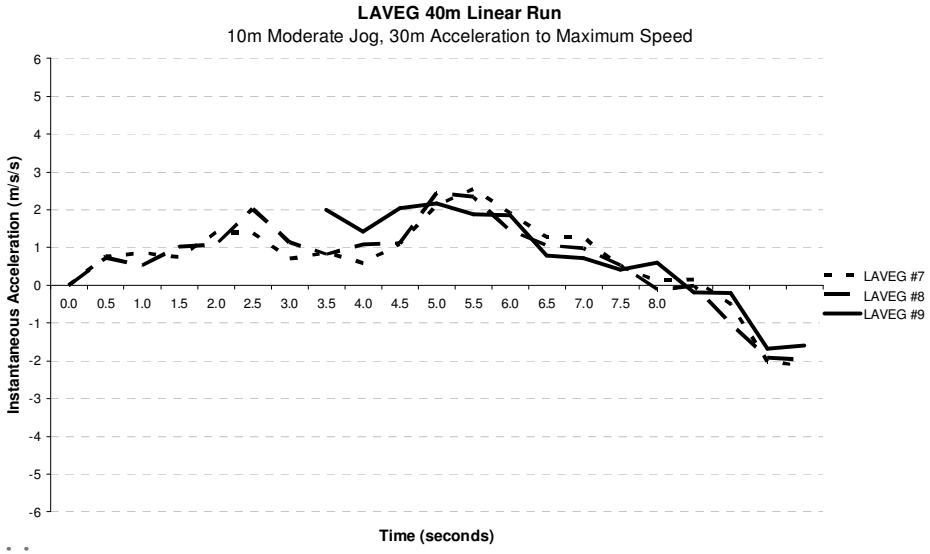
Results & Analysis



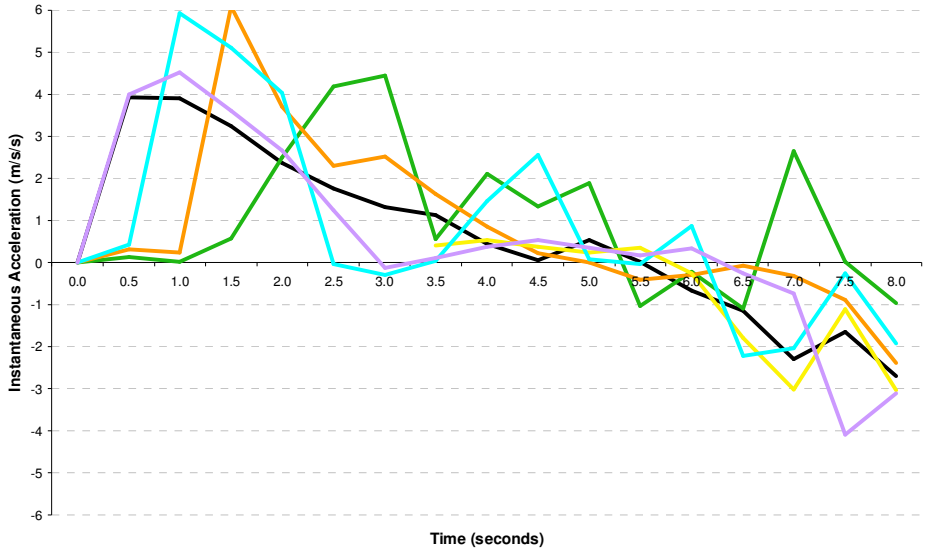
Tests 1-3: LAVEG Accel/Decel Profiles

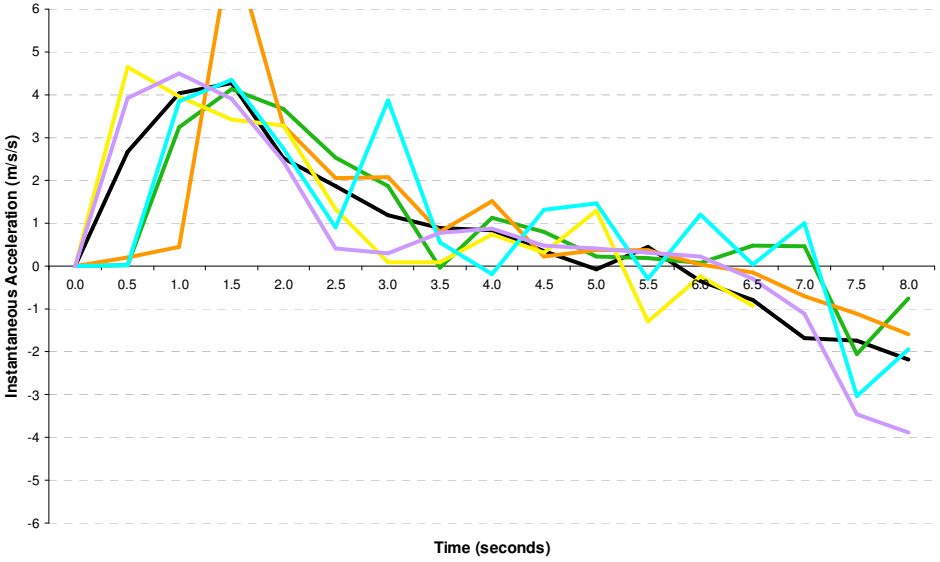


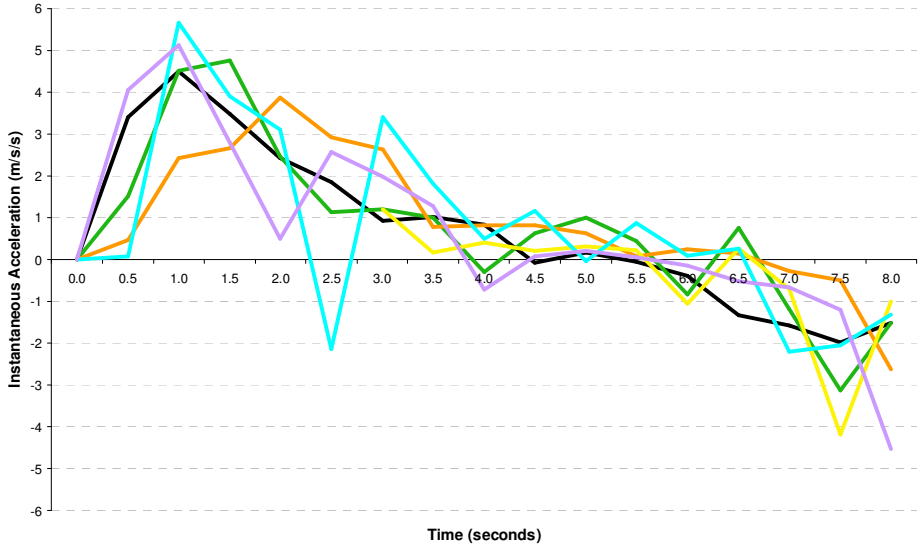




Test 1: Explosive Sprint Accel Profiles







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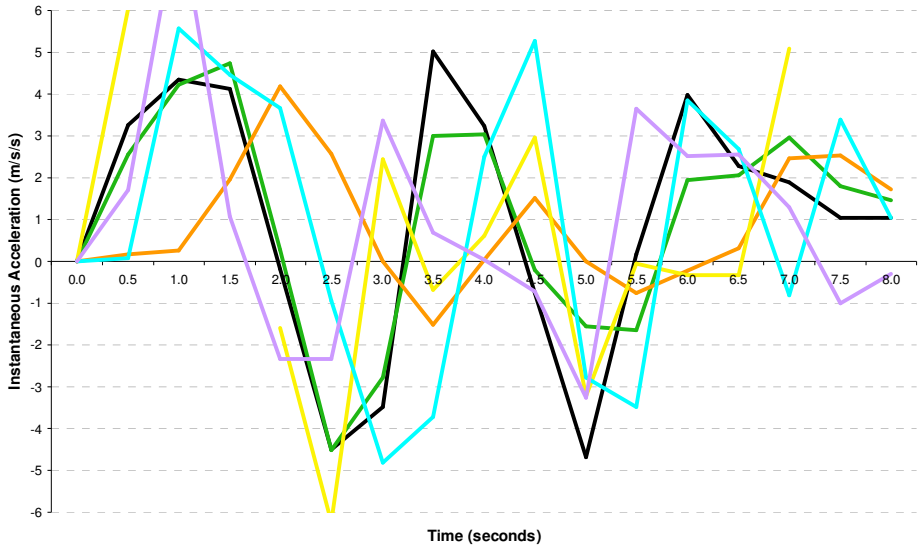
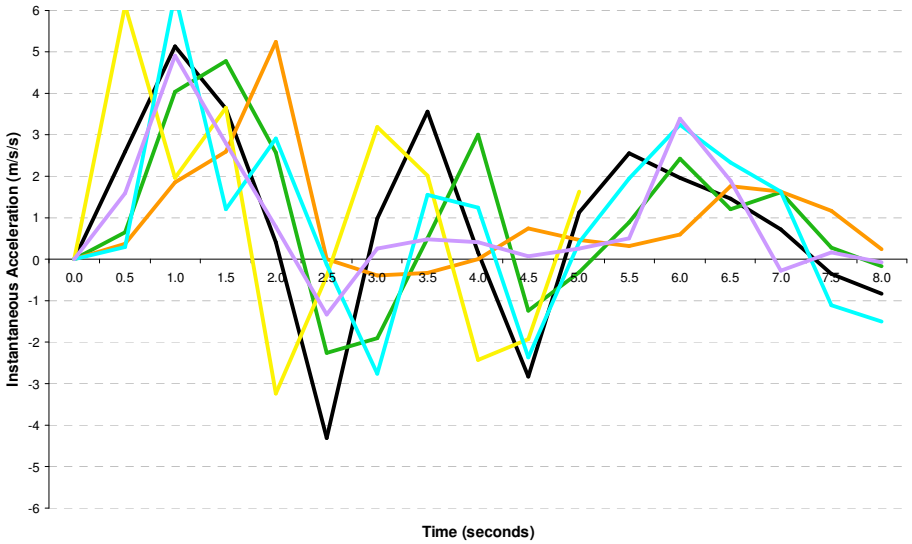
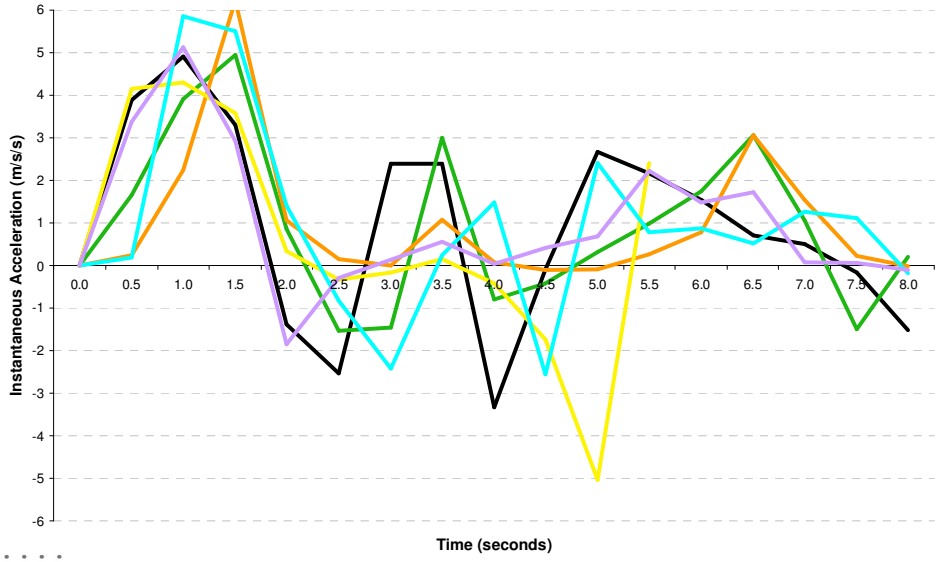
Test 1: Explosive Sprint

Acceleration to maximum speed from a stationary start over 40m, sustain speed and run through gate **(x3)**

Test 2: Variable Sprint Accel Profiles







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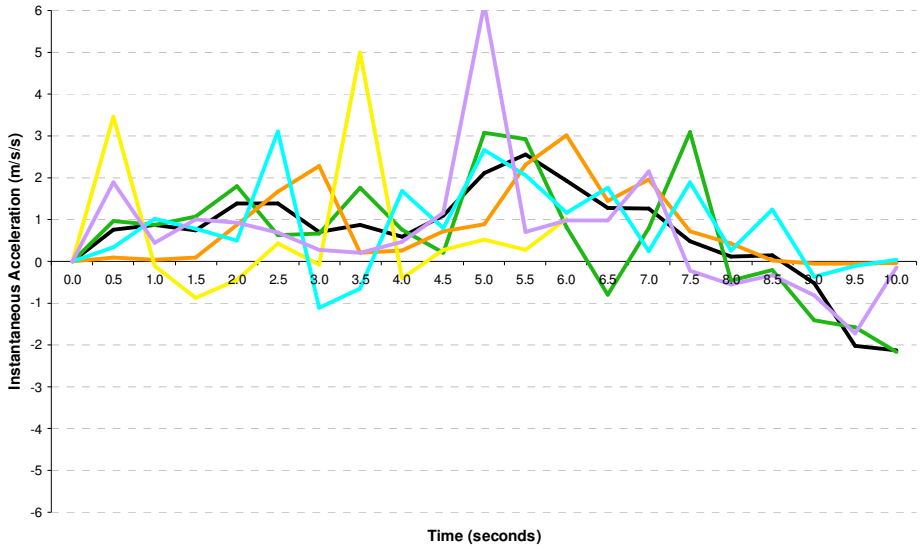
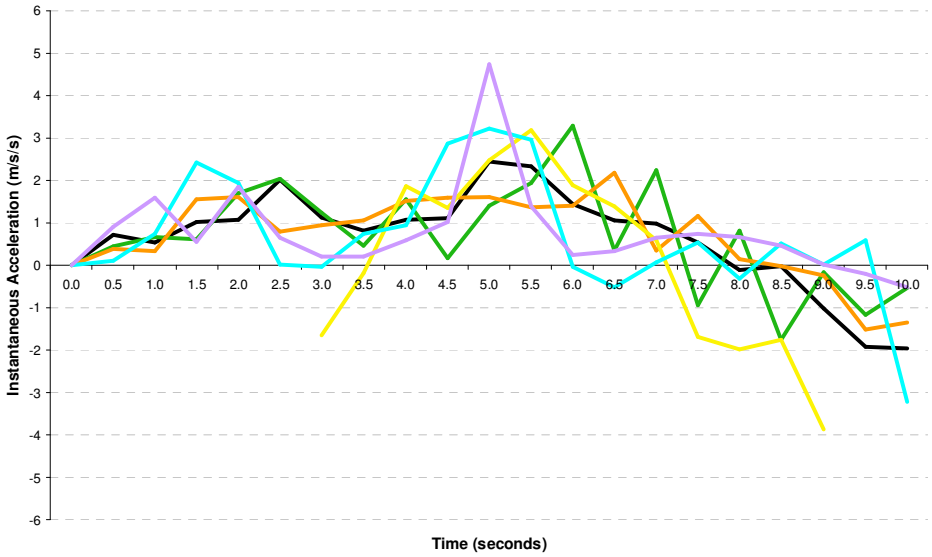
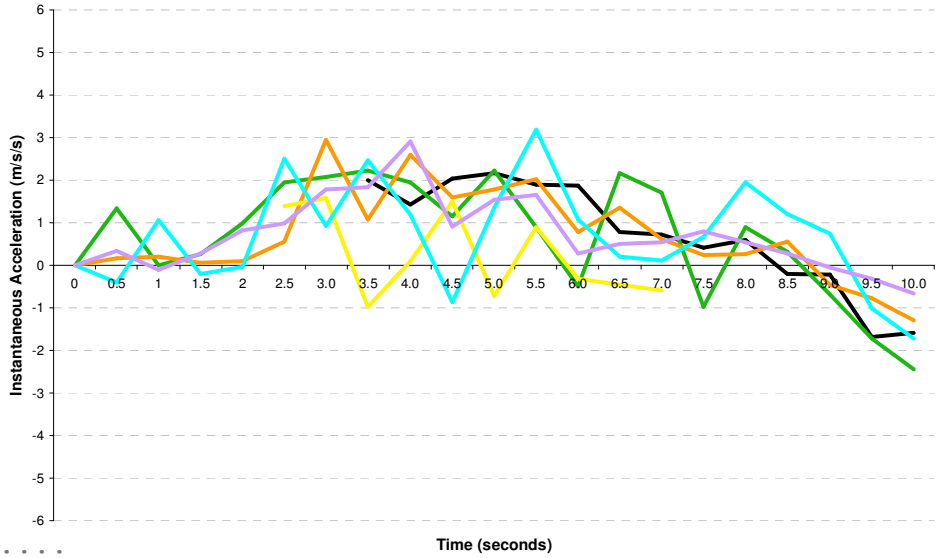
Test 2: Variable Sprint

From a stationary start, 10m accel/decel to stationary, 10m accel/decel to stationary, 20m acceleration to maximum speed and run through final gate **(x3)**

Test 3: Leading Sprint Accel Profiles







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Test 3: Leading Sprint

10m moderate jog from stationary start, 30m acceleration to maximum speed and run through final gate **(x3)**

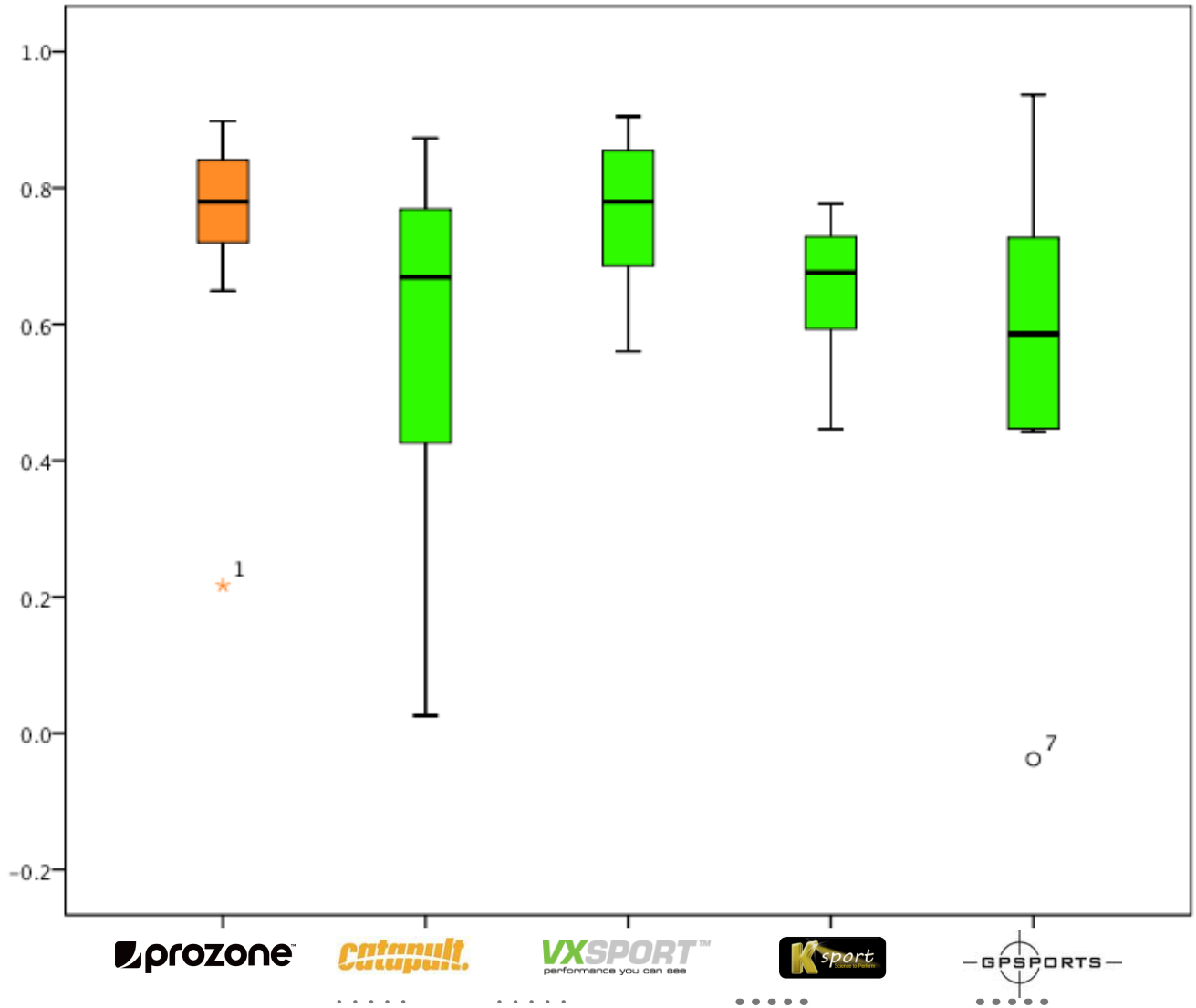
Accel/Decel Correlation vs LAVEG

Pearson's correlation coefficient calculated from acceleration/deceleration measurement profiles using SPSS software.

		prozone	catapult	VXSPORT performance you can see	K sport	GPSPORTS
40m Explosive Sprint	Sprint #1	0.217	0.650	0.905	0.732	0.937
	Sprint #2	0.841	0.769	0.900	0.777	0.865
	Sprint #3	0.891	0.758	0.855	0.729	0.727
40m Variable Sprint	Sprint #4	0.898	0.026	0.560	0.481	0.447
	Sprint #5	0.720	0.316	0.751	0.676	0.599
	Sprint #6	0.649	0.426	0.794	0.446	0.442
40m Leading Sprint	Sprint #7	0.784	0.669	0.618	0.593	-0.038
	Sprint #8	0.751	0.867	0.686	0.689	0.586
	Sprint#9	0.780	0.873	0.780	0.670	0.546
	Average:	**0.726**	**0.595**	**0.761**	**0.644**	**0.568**

Accel/Decel Correlation vs LAVEG

Pearson's correlation coefficient calculated from acceleration/deceleration measurement profiles using Minitab software.



Discussion

- Comparing data capture across all 9 sprints the VX Sport data has the best overall correlation with the LAVEG control for speed (0.962) and acceleration/deceleration measurement (0.761).

- Some research studies concerned with the validity of GPS enabled technologies for speed and acceleration have reported that higher GPS sample rates provide more accurate data, however the findings in this initial study do not support this directly.

- Prozone optical tracking data achieved the second best overall correlation compared with the LAVEG control for speed (0.940) and acceleration/deceleration measurement (0.726).

- The greatest speed measurement variability was observed with data obtained from GPSports software and this was partially due to temporary loss of data during the majority of the sprint activities. The reason for the data loss is not known but could be due to loss of satellite signal or issues with the antenna.

- The greatest acceleration/deceleration variability was observed with data obtained from Catapult which appears to apply a higher level of data smoothing within the software relative to the other technologies. This smoothing process also appears to cause a small time lag of 0.5-1.0 secs relative to ‘actual time’.

- Ultimately the underlying GPS technologies used within the different monitoring devices assessed are relatively similar, however there are more significant differences in how the ‘raw’ GPS data is post processed in order to smooth/filter and provide error checking. Caution should therefore be applied when comparing output data from different tracking technologies where post processing techniques and algorthims are not fully understood.

Recommendations for Further Work

- This study assessed physical measurement data for a set of linear high intensity activities, however further work is required to further assess measurement validity in non-linear longitudinal data capture as well as quantifying repeatability and reliability.

- To further validate the findings within this study, the test protocol should be repeated - once at the same location and again at an alternate location (ideally in a different part of the world). The objective would be to assess if the findings are repeatable and therefore reliable.

- The analysis in this initial study was conducted based on 0.5 second work units for consistency with existing Prozone product algorithms, however it would be worthwhile to re-conduct the analysis based on 0.1 second work units to verify if there is any significant change in the correlations.

- In this study, we positioned multiple GPS units within relative close proximity and further research is required to understand if this could result in potential signal interference which affects the accuracy of data capture. A subsequent study should focus on monitoring an object moving in a controlled manner (and a highly repeatable speed profile) with multiple configurations of GPS monitoring units.

- This study focused on comparing measurement accuracy of specific linear high intensity activities, however we also need to assess the capability of the various technologies to record longitudinal data capture over an extended period with a subject performing a multi-directional movement activity pattern consistent with match performance. This should form the basis for a future study which compares multiple GPS device configurations.