THE RELATIONSHIP BETWEEN ACCELEROMETRY AND TOTAL DISTANCE MEASURED WITH GPS IN WOMEN'S COLLEGE SOCCER

Christine L. Coniglio[1], Kyle Travis[1] and Jeremy A. Gentles[1]

[1]East Tennessee State University, Department of Sport, Exercise, Recreation, and Kinesiology

INTRODUTION: The prevalence of microsensors such as global positioning systems (GPS), accelerometers, and heart rate monitors have improved the ability of sport scientist and coaching staff to monitor training loads. While each of these systems have their advantages, using multiple sensors generates more data and metrics than most coaches can be expected to understand. Reducing the number of sensors may increase the efficiency of data analysis and interpretation by reducing the number of metrics.

GPS can be used to quantify the total distance and distance in speed zones for a variety of sports(Cummins 2013; Dwyer 2012). While it is generally agreed upon that GPS accuracy improves as distance increases (Beato, 2016; Castellano, 2011), GPS sampling at 5-15 Hz is suggested to improve accuracy (Coutts, 2010; Vickery 2014), with some evidence recommending no less than 10 Hz (Rampinini, 2015; Varley, 2012). The discrepancy in sampling frequency recommendations may also be a result of different algorithms to calculate distance and speeds between devices sampling at different rates (Coutts, 2010). However, the circular error probability (CEP) of GPS has been reported to be approximately 1-5 m (Duncan, 2013; Scott, 2013), meaning that 50% of an athlete's recorded positions will be within 1-5 m of the athlete's true position. Regardless of sampling frequency and algorithm/filter used, GPS will likely misrepresent position, distances, and speeds due to accuracy limitations, particularly in sports which require repeated changes of direction.

Accelerometers and inertial measurement units (IMU) have been used to quantify workloads in a variety of sports (Colby, 2014; Gescheit, 2015) and are most often measured with triaxial accelerometers and reported as the sum of acceleration in three movement planes (side-to-side; forwards-backwards; up-down). Accelerometers provide potential benefits over GPS as they measure all movement and can be used to quantify the number of accelerations and decelerations, number and magnitude of impacts, step and jump counts and a variety of other variables (Cardinale, 2017). Accelerometers also function indoors, satellites are not required and do not suffer from the same potential loss of signal that GPS does. Accelerometers and GPS are frequently combined into the same unit allowing GPS- and accelerometry-based workloads to be collected. A strong relationship between total distance and accelerometry based workloads have been reported (Polglaze, 2015; Scott, 2014). Previous research has used accelerometry-based workloads such as Player Load (PL) to examine this relationship ($r=0.70$, $p < 0.01$) during soccer match play (Casamichana, 2013). PL is the sum of the differences between accelerations, which is not an indicator of total work; PL calculations include accelerations of non-locomotor origin, including any movement of the torso while seated and/or standing in place. However, Buchheit et al. (2017) suggest accelerometry based workloads such as Force load (FL) may be a more precise indicator of total work, providing the sum of the magnitude of all accelerations, and only includes accelerations from locomotor activities and impacts (Buchheit, 2017). Therefore, the purpose of this study was to assess the relationship between total distance and accelerometry derived measures of locomotor activity in women's college soccer.

METHODS

Subjects: Twenty-five NCAA Division II women's soccer players (age, 20.2 yrs. ± 1.1; height, 166.3 cm ± 5.9; weight, 62.0 kg ± 7.0) participated in this study. Each athlete was assigned and familiarized with the wear and operation of the Zephyr™ BioHarness (BH; Zephyr Technology Corporation, Annapolis, MD) during preseason training. Each BH included a Biomodule (version 3) and strap. Athletes were equipped with a BH that was worn during competition. The BH strap was placed at the level of the xyphoid process and the Biomodule was positioned on the midaxillary line. The Biomodule contains a HR sensor and triaxial accelerometer which sample at 250 Hz and 100 Hz, respectively. BH data was downloaded to and analyzed with OmniSense™ Analysis (version 4.1.4; Zephyr Technology Corporation, Annapolis, MD). GPS units (BT-Q1300-S GPS, Qstarz International Co., Taipei, Taiwan) sampling at 5 Hz were also worn by each participant. Each GPS unit was attached to the BioHarness strap and interfaced with Biomodule via Bluetooth. This investigation was approved by the Institutional Review Board and all participants completed and signed University approved informed consent.

Match Time: Data was collected on 25 players over an entire regular season (23 practice sessions, 17 match play warm ups, 17 matches). All BH and GPS units were powered on by the researchers prior to the start of each session. Data collected in each of the sessions was categorized as practice (PR), warm-up (WU) and match play (MP). PR included all practice sessions during the regular season. WU included all activities prior to the beginning of MP. MP included two-45 minutes halves, a 15 minute half-time and overtime periods if they occurred; only three overtime periods occurred during the season. A total of 1119 practice and game segments were analyzed (407 PR, 287 WU and 305 MP).

Accelerometry: Gravitational forces (1 g = 9.81 m/s^2) were recorded to describe acceleration data collected from BH. Total mechanical loads for MP were expressed as Impulse load (IL). IL is the accumulated mechanical load equal to the sum of areas under the 3-axis accelerometry curves and expressed as N*s. IL only includes detected locomotor events (e.g., walking, running, jumping) and impacts. Mean IL were calculated for WU and MP. The formula for IL is displayed below where x = g forces in the medio-lateral (“side-to-side”) plane, y = g forces in the anterio-posterior (“forwards and backwards”) plane, z = g forces in the vertical (“up and down”) plane.

$$Impulse\ Load = \sum_{s=1}^{n} \frac{\sqrt{x_s^2 + y_s^2 + z_s^2}}{9.8067}$$

GPS: GPS units were used to collect total distance (TD, km) during PR, WU and MP. All GPS units were turned on approximately 10 minutes prior to use to ensure satellite signals were acquired. Invalid GPS data, such as zero distance recorded or excessive peak speaks, were removed from analysis.

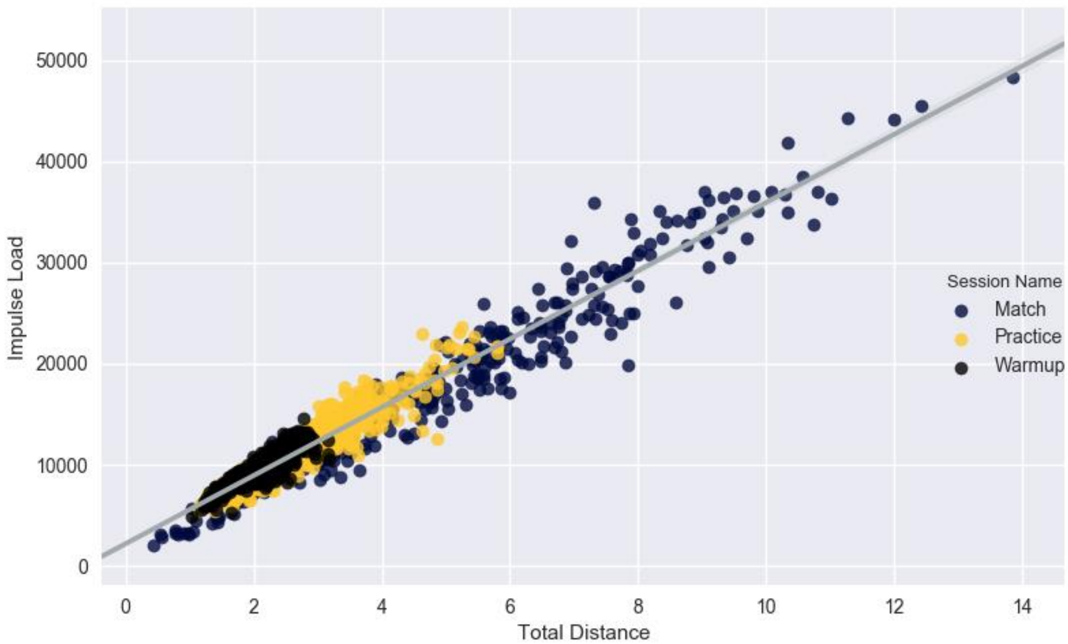
Statistics: Means and standard deviations (SD) were calculated for TD and IL. A linear regression analysis was used to create a predictive model of TD as the dependent variable using IL as the independent variable. The level of significance was set at $p \leq 0.05$ for all statistical analysis. Statistical procedures were completed using JASP (version 0.8.0.3).

RESULTS: TD was 3.40 ± 1.98 km and IL was 13,680 ± 6,876 N*s. Linear regression established nearly perfect and statistically significant relationship (R^2= 0.944, r= 0.971, p<0.001) between TD and IL during all regular season sessions (PR, WU, MP). This model suggest that IL accounted for 94% of the variability in TD. Figure 1 illustrates the relationship between TD and IL. The resulting linear regression is shown below.

$$TD = (.0003 \times IL) - 0.422$$

DISCUSSION: This research discovered a nearly perfect (Cohen, 1977)and statistically significant relationship between IL and TD in women's college soccer. Therefore, our results suggest IL can be used to predict TD in women's college soccer. IL differs from other accelerometry-based workloads, in that IL only includes locomotor activity and impacts. This may provide benefits over other accelerometry-based workloads, such as PlayerLoad (Barrett, 2016), which includes all accelerations of the torso in activities such as cheering on sideline, standing up and down, or stretching on the ground. The benefits of using accelerometry workloads that only include locomotor activity has been recognized previously (Buchheit, 2017), but limited examples currently exist in the literature related to workloads in sport (Colby, 2014). Since GPS is often used to determine TD traveled and time spent in different speed zones, future research should address whether accelerometry-based workloads can be used to quantify time spent in different stepping events such as walking, running, and sprinting.

Figure 1. Relationship Between TD and IL



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