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Abstract

Rugby sevens is a widely practiced sport that combines high-speed anaerobic activity with positional specific play and many body impacts. Despite its popularity and its intense physical demands on the body, many of these demands have not been fully explored. An investigation into the specifics of these physical demands can aid coaches and athletes in training and preparation for future matches. The purpose of this study was to quantify the Impulse Load and movement dynamics placed on American rugby players during competition. With this data, position specific information was compared to determine differences in physical demands. Fourteen male collegiate rugby sevens players were assigned a microsenor device and bioharness prior to testing. Time motion analysis data was collected using these microsenor devices. Acceleration data was used to calculate Impulse Load and GPS data was used to quantify total distance and distance in six speed zones. The devices were placed on each player, securely fastened around the chest, and worn for the duration of the warm-up and two competitive matches, for a period of 1 hour and 47 minutes. Players were monitored using 5Hz global positioning systems (GPS) and 100Hz triaxial accelerometers. Players were further analyzed and divided by playing position (forwards and backs). The contrasts in physical demands based on position can provide feedback to coaches on position-specific training.Faculty Advisor: Brandi Eveland-Sayers

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Playing at Sevens: The Impulse Load and Movement Demands of Men’s Collegiate Rugby

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Abstract
Rugby sevens is a widely practiced sport that combines high-speed anaerobic activity with positional specific play and many body impacts. Despite its popularity and its intense physical demands on the body, many of these demands have not been fully explored. An investigation into the specifics of these physical demands can aid coaches and athletes in training and preparation for future matches. The purpose of this study was to quantify the Impulse Load and movement dynamics placed on American rugby players during competition. With this data, position specific information was compared to determine differences in physical demands. Fourteen male collegiate rugby sevens players were assigned a microsenor device and bioharness prior to testing. Time motion analysis data was collected using these microsenor devices. Acceleration data was used to calculate Impulse Load and GPS data was used to quantify total distance and distance in six speed zones. The devices were placed on each player, securely fastened around the chest, and worn for the duration of the warm-up and two competitive matches, for a period of 1 hour and 47 minutes. Players were monitored using 5Hz global positioning systems (GPS) and 100Hz triaxial accelerometers. Players were further analyzed and divided by playing position (forwards and backs). The contrasts in physical demands based on position can provide feedback to coaches on position-specific training.

Keywords
Impulse Load, movement demands, rugby

Peer Review
This work has undergone a double-blind review by a minimum of two faculty members from institutions of higher learning from around the world. The faculty reviewers have expertise in disciplines closely related to those represented by this work. If possible, the work was also reviewed by undergraduates in collaboration with the faculty reviewers.

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Since its foundation, Rugby Union has evolved into a complex field sport played by both men and women of all ages and levels. Rugby sevens is an abbreviated version of the Rugby Union game in which each team has only seven players on the field and play on a standard size Rugby Union field, but with a shorter duration of only seven-minute halves. Rugby sevens is an intermittent high intensity game that combines periods of high-speed sprinting and collisions (running, jumping, tackling) with low intensity actions (walking). Players are divided by position into forwards or backs.

Despite its recent increase in global popularity, there is a lack of research regarding the locomotive and physical demands of rugby and especially rugby sevens. Though there is an increasing amount of literature concerning men's Rugby Union internationally, there is still a great need for research in rugby sevens played in America. Several studies have been completed regarding movement and physical demands in elite Rugby Union (Coughlan et al., 2011; Cunningham et al., 2016; Deutsch et al., 1998; Cunniffe et al., 2009; Read et al., 2017). These studies have utilized time motion analysis (TMA) and GPS (Global Positioning System) devices to quantify and analyze movement demands.

A number of authors have reported positional differences in demand requirements. Just recently, Read et al. (2017) quantified the physical demands of adolescent Rugby Union players. This study found a contrast of differences between backs and forwards, reinforcing the need for exposure to position specific training. This information can greatly aid those who develop training programs for rugby sevens players. Position specific training can be an individualized way for coaches and trainers to manage the mechanical load and injury prevention for these athletes.

Wearable microsensor technology is a widely-used form of movement analysis in field team sports to quantify movement demands on players during training and competition (Cardinale & Varley, 2017; Cunniffee et al., 2009; Cunningham et al., 2016; Deutsch et al., 1998; Gabbett et al., 2018). Practitioners and coaches use the data provided by these wearable devices to better understand the demands placed on players during competition or practice. Global Positioning (GPS) tracking is a satellite navigational system that provides information on location and time. GPS systems provide information to better understand the physiological requirements of performance by tracking total distance and distance within certain speed zones.

Despite the popularity of GPS use in sports, the units have limitations that should be addressed. Environmental factors can obstruct the communication between the GPS chipset and satellite resulting in positional error (Duncan et al., 2005). GPS has also been found to misrepresent position, distance and velocity due to accuracy limitations (Cardinale & Varley, 2017). The validity of GPS devices for measuring distance and velocity has been shown to decrease at higher velocities (Barlett et al., 2017). This error is often a result of quick directional changes and high intensity movements, both aspects found in the sport of rugby sevens.

Accelerometers are another form of wearable technology that have also been used to quantify movement demands and workload. Accelerometers measure the sum of acceleration in three separate movement planes. These devices are far more sensitive and can detect all movement and effort at high speeds as compared to the GPS unit (Cardinale & Varley, 2017). Accelerometers are used to identify the quantity and magnitude of locomotor events. This information details decelerations, accelerations, magnitude of impacts, step and jump count along with several other variables. Often, accelerometers and GPS units are combined in the same wearable unit allowing their raw data to complement one another during analysis. Impulse Load is a measure of mechanical load that includes only locomotor related accelerations (Gentles et al, 2018).

With this in mind, the purpose of this study was to use microsensor technology (accelerometer and GPS) to quantify the Impulse Load and movement demands placed on American collegiate rugby athletes during competition.

Methods

Subjects. Fourteen male collegiate rugby sevens players (age 19.64 ± 1.01 years, height 173.46 ± 8.19 cm, weight 86.86 ± 17.96 kg) participated in this study. Institutional Review Board approval was granted and written consent was obtained from all participants. Players were randomly assigned a microsenor testing unit. Data were collected during two matches. Players were further divided into forwards and backs. All players were considered healthy and injury-free at the time of the assessment. Match one had an official playing time of 15 minutes and match two had an official playing time of 16 minutes (excluding halftime). An official time was kept throughout the testing period and observation of player substitutions were collected. There were repeated measures for individual players as data were collected and broken down in sub-sessions by each half of each match. Substitutions of players were recorded in each match. Only the data of those who played at least some portion of the matches were analyzed (i.e. athletes on the sideline who did not enter the match were eliminated from analysis).

Procedures. During the warmup and the two matches, each player wore a randomly assigned microsensor-based technology unit that contained both a GPS and a tri-axial accelerometer. The data was captured at a sampling frequency of 5 Hz (GPS) and 100 Hz (accelerometer). Variables that were collected consisted of distance in six speed zones, total distance, step count, jump count, bound count, Impulse Load, and minor/major impact count. The six speed zones were: 1.0–4.99 kph (Zone 1); 5–9.99 kph (Zone 2); 10–14.99 kph (Zone 3); 15–19.99 kph (Zone 4); 20–24.99 kph (Zone 5); 25 kph and greater (Zone 6).

The Zephyr™ units were placed within a secure bio harness that was fashioned around the players' chests. The device was situated at the level of the xyphiod process and the midaxillary line on each player. All participants wore the device during warm up to familiarize themselves with the unit before match play.

Data Analysis. Descriptive data are represented as the mean ± SD and minimum and maximum values. A Pearson correlation was performed on Impulse Load and total distance. Only data from the actual playing time were analyzed. Data were analyzed using JASP (version 0.8.3.1) and are displayed as means and standard deviations.

Results

Movement only demands were determined by total distance and distance in six relative speed zones; this data was derived from the GPS microsensor device. Movement demands focus primarily on distance and speed as stressors on the body. Backs traveled a distance of 0.45 ± 0.31 km and forwards traveled 0.37 ± 0.27 km. The mean ± SD of GPS derived variables are presented in Table 1, illustrating the average speed traveled across six different speed zones. These results are divided by position (forwards and backs) for comparison. Backs traveled, on average, a greater distance in speed zones faster than 5 kph. Forwards were found to spend majority of playing time traveling at speeds 1-4.99 kph. Figure 1 displays the distribution between distance traveled and position, again divided into the six speed zones. The shape of the distribution indicates how the distance traveled relates to the average speed in each zone.

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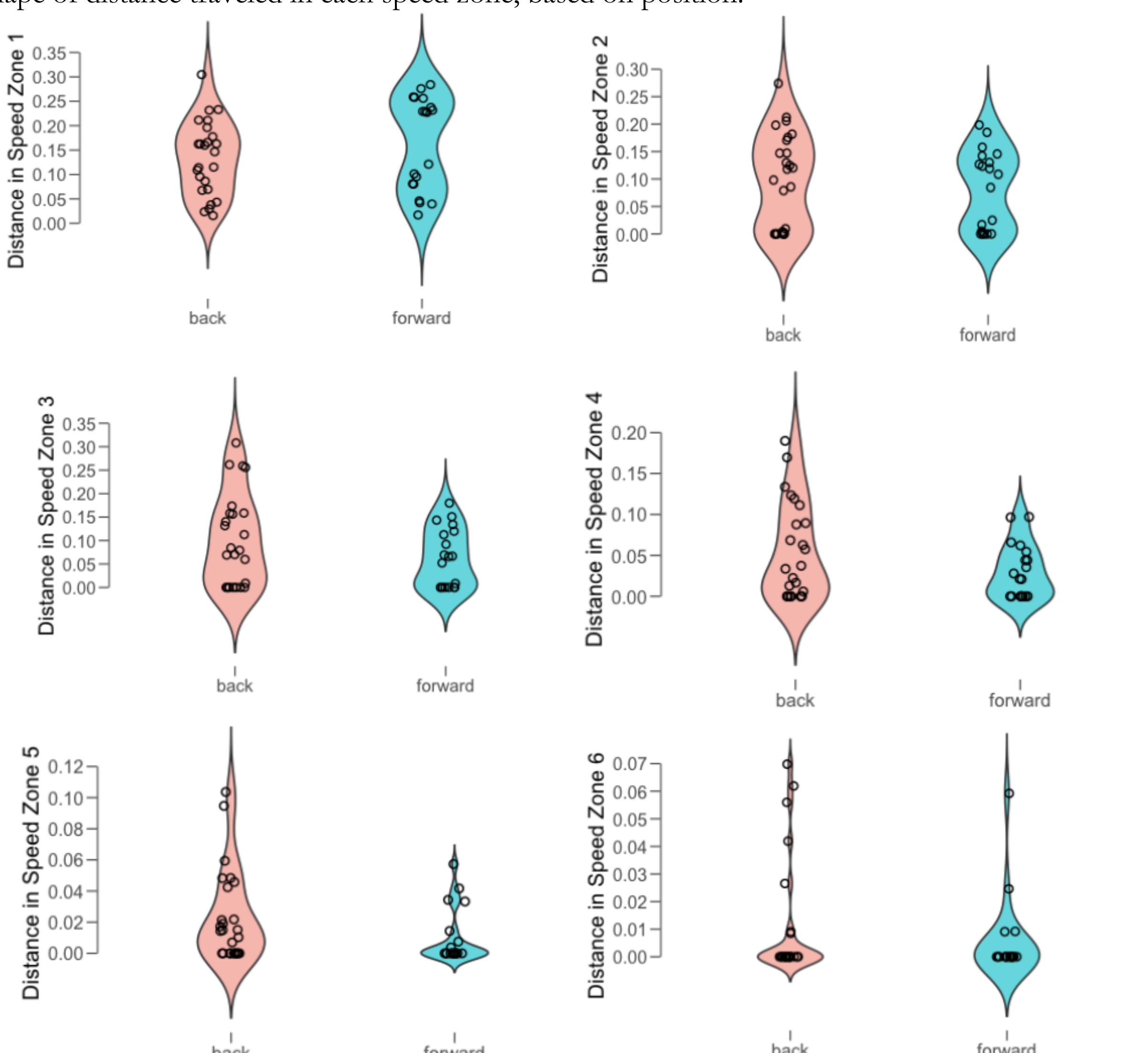
Table 1. Distance (km) in Speed Zones

SPEEDZONE	1	2	3	4	5	6
Backs						
Mean	0.133	0.099	0.099	0.054	0.023	0.011
Std. Deviation	0.076	0.086	0.098	0.059	0.029	0.022
Minimum	0.016	0	0	0	0	0
Maximum	0.305	0.274	0.308	0.19	0.104	0.07
Forwards						
Mean	0.164	0.082	0.063	0.03	0.01	0.005
Std. Deviation	0.096	0.072	0.062	0.033	0.018	0.014
Minimum	0.017	0	0	0	0	0
Maximum	0.284	0.198	0.18	0.097	0.057	0.059

Note: distances (km) split by position (forwards and backs) in six speed zones: (1) 1.0-4.99 km/hr, (2) 5.0-9.99 km/hr, (3) 10.14.99 km/hr, (4) 15.0-19.99 km/hr, (6) >25 km/hr

Figure 1. Distribution of distance by position. Figure one uses a violin plot to display distribution shape of distance traveled in each speed zone, based on position.



Physical demands were determined and quantified by using the tri-axial accelerometer data. Physical demands are characterized by aerobic ability and intermittent exercise performance demands; these demands were quantified using variables such as walk step count, run count, jump count, total steps, Impulse Load, and minor/major impacts. Mean Impulse Load and total distance during match play were 1373.59 ± 0.414 N*s, 0.41 ± 0.29 km. Analysis revealed a nearly perfect correlation between Impulse Load and total distance ($r = 0.977$, $p = < .001$). Figure 2 illustrates the positive correlation found between Impulse Load and total distance.

When analyzing impacts based on position, it was found that backs experienced a larger average of minor impacts when compared to the forward players. Table 2 illustrates positional specific impacts during match play. The results presented in this table show the average cumulative count of both major and minor impacts. Both backs and forwards experienced a greater number of minor impacts than major impacts. Backs, however, were found to have encountered a greater number of major impacts than the forward players.

Table 2 also displays an unexpected finding of this data sample. A standard deviation greater than the mean was found for both minor and major impacts regardless of position. This analysis reveals that there is a large spread of observation about the mean. This large spread of observation could be a result of a relatively small sample size.

Figure 2. The relationship between Impulse Load (N*s) and total distance (km). Impulse Load is a measure of accumulated acceleration and was measured using accelerometers. Distance was measured via GPS. The strength of the relationship between Impulse Load and Distance indicates that Impulse Load may be an indicator of total distance and/or work in rugby.

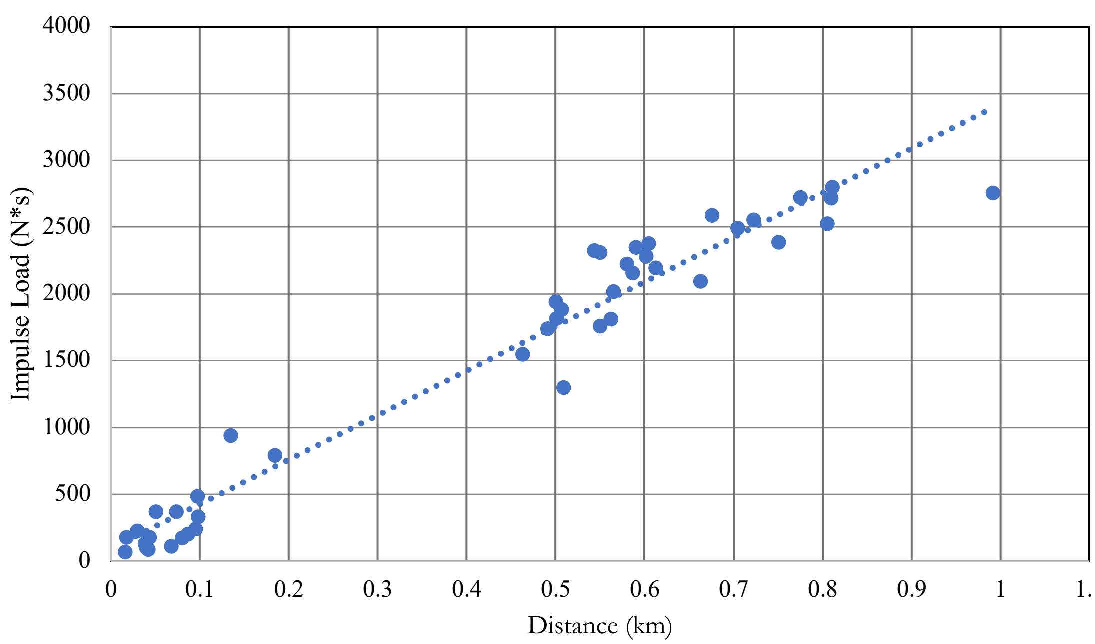


Table 2. Cumulative Count of Major and Minor Impacts During Competition

	Minor Impacts 3g to 7g	Major Impacts >7g
Backs		
Mean	30.66	3.16
Std. Deviation	31.71	4.39
Minimum	0	0
Maximum	103	13
Forwards		
Mean	18.71	2.08
Std. Deviation	24.31	3.73
Minimum	0	0
Maximum	100	16

Discussion

The purpose of this study was to quantify movement demands and Impulse Load in American collegiate rugby sevens players during competition. Impulse Load is a cumulative measure of acceleration and can represent the acceleration an athlete experiences during an impact. Impulse load is defined as a cumulative measure of mechanical load that is equal to the sum of the area under the accelerometry curve (Zephyr Technology, 2016). Impulse Load includes only activities of locomotive movement (e.g., walking, running, bounding, jumping and impacts), increasing its reliability when considering the physical demands placed on athletes during competition. These data demonstrate a nearly perfect relationship between Impulse Load and total distance ($r=0.977$, $p=<.001$) suggesting Impulse Load is an excellent indicator of total distance. Gentles and colleagues (2018) found similar results regarding Impulse Load and total distance when investigating the demands of soccer players.

The mean and standard deviation for total distance and Impulse Load indicate that backs traveled a greater distance and experienced more cumulative impacts (minor and major) when compared to forwards. These findings confirm that backs in this sample demonstrate greater movement and physical demands.

Past research has also demonstrated positional differences during match play. Using a similar GPS device, Deutsch et al (1998) used motion analysis and found that backs covered a greater overall distance when compared to forwards. Motion analysis completed by Coughlan et al. (2011) also indicated backs covered a greater distance during match play. Previous investigation has also explored time and distance traveled in different speed zones (Coughlan et al., 2011; Deutsch et al., 1998). Most of this research focused on elite Rugby Union players rather than rugby sevens players on the collegiate level.

Positional differences in distance traveled and mechanical load indicate that each player and playing positions have unique characteristics. This may imply that individualization is a key model in developing training programs (López et al., 2014).

Available literature suggests that the higher the velocity of movement, the lower the GPS accuracy. GPS reliability is also reduced when assessing movements that require quick changes in position (Halson, 2014; Malone et al., 2017). This again may suggest that accelerometry is a better potential training load monitoring tool.

Implications

As athletes strive to improve performance, modifications in training load are required to prevent overtraining resulting in injury. Many strength and conditioning coaches, practitioners and athletes are taking a more scientific approach when designing appropriate training programs (Halson, 2014). When developing such programs, it is important that mechanical load is gradually increased throughout the season to promote optimal conditioning. A large amount of repetitive mechanical load can lead to injuries such as stress fractures, shin splints, joint pain and several other "over use" complications (Zephyr Technology, 2016).

The primary goal of an individualized training program is to improve performance of characteristics specific to playing position. (López et al., 2014). Quantification of these characteristics with the use of microsensor technology is an ideal way to evaluate training loads.

When designing a conditioning program for a contact sport such as rugby sevens, Impulse Load or total distance should be considered. Positional monitoring using microsenor devices (accelerometer and/ or GPS) during an entire season of training and competition would provide information to effectively design a positional specific training program (Coughlan et al., 2011).

In conclusion, this investigation summarizes the movement demands and Impulse Load placed on collegiate rugby sevens players during competition. Backs cover a greater distance and are involved in more impacts when compared to forwards. This study was one of the first to use microsensor technology, including accelerometers, to explore the physical demands placed on American collegiate rugby sevens players during match play. The results of these demands can aid in program training and recovery for athletes to adequately prepare them for the locomotive and impact stress during competition. Future research using microsensor technology is required to further explore the physical and physiological demands of American collegiate rugby sevens.

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