Reliability of Zepp Baseball on Batting Velocity

Raja Nurul Jannat Raja Hussain

Kee Kang Mea

Rizal Mohd Razman

Shariman Ismadi Ismail

Maisarah Shari

Norizzati Mohd Idris

Rozella Abdul Razak

Nur Atikah Mohamed Kassim

ABSTRACT

In baseball and softball sports, one of the important characteristic of a successful hitter is having a fast bat swing velocity. Therefore, it is crucial to measure changes of batting velocity in training and during competitive matches. This paper quantifies the reliability of a small wearable sensor that was designed to be used in baseball and softball sports. An inertial measurement unit (IMU) manufactured by Zepp Lab, USA was used to measure the batting velocity in softball. A single female collegiate softball player completed sixty tee swings of two pre-determined swing velocities. Results from moderate velocity Vm (25.5 ± 3.5 m/s), and fast velocity range Vf (34.5 ± 3.5 m/s) were obtained. Data were collected concurrently with a 3- Dimensional (3D) motion analysis system (Qualisys Motion Capture). The reliability of the IMU was determined based on the Pearson Correlation and Intraclass Correlation (ICC) values between the IMU and the 3D data. Results indicated strong and moderate correlation between the IMU and the 3D data (Vm, r = 0.89; Vf, r = 0.59). The ICC for Vm (0.89) showed strong agreement, while fair agreement showed for Vf (0.37). However, for a total of sixty swings of two different velocities showed almost perfect agreement (ICC = 0.94). These results indicate that the Zepp Baseball device has an acceptable level of reliability in measuring batting velocity during different swing velocity ranges and it is suitable to be use in a softball-related research environment.

Keywords: *Qualisys, IMU, swing, softball, technology.*

Introduction

Athletes of today are becoming faster and stronger through better nutrition intake and training. Old records are constantly being broken, and new ones set. Though the majority of these success are likely due to the athletes' ability, developments of sports technology have also play a vital role. Sports technology have been designed at all levels of sports play such as from low level of recreational activities to high level of competitive sports. A good example of recent applied technology in sports is the use of "smart" devices that incorporates sensors and computers as a part of their function. These devices was designed by Zepp Lab, USA. These devices are helpful in measuring human performance evaluation as a part of their training regimen. Zepp Lab produced several sensor devices for various sports such as baseball and softball, golf, and tennis. However these new technology based approaches to measuring athlete's performance need to be tested for reliability. These devices allow instant feedback on athlete's performance (e.g.: velocity, angle, speed) which it usually can be measure through 2-Dimensional and 3-Dimensional motion analysis. However, those methods were highly in cost and were conducted in lab based. Therefore, not all of the athletes and teams have chances to measure their performance in following ways. The parameters are important due it able to help the coaches to know their athlete's current performance and help the athletes in improving their performance too.

This study focused on finding the reliability of Zepp Baseball on measuring the velocity of softball swing. Sports such as softball involved swing movement (batting) which required high swing speed. In softball and baseball, one of the important characteristic of successful hitters is having fast bat swing velocity (Hughes, Lyons, & Mayo, 2004; Szymanski, DeRenne, & Spaniol, 2009; Szymanski et al., 2007; Wilson et al., 2012). It reflects a good hitter as it rewards more time for batters to react to the pitch. Increasing bat swing velocity can lead to an increased player's decision time, decreased player's swing time and increased batted ball velocity (Szymanski et al., 2009). When the batters have long decision time, he or she able to wait longer before contact. In result, the batter can generate more accurate contact and from that, it will increased the batted ball velocity simultaneously increase the distance of ball travel.

The ability to measure velocity of the bat swing is an important component for testing batting performance in softball and baseball players. This test is reliable and able to help the players to determine their level of batting velocity and help coaches to estimate the batted ball speed. One of the method to measure bat swing velocity is through motion capture system which using high speed cameras that eventually very expensive (Ae & Koike, 2011; Chang et al., 2011; Crisco, Greenwald, Blume, & Penna, 2002; Greenwald, Penna, & Crisco, 2001; Inkster, Murphy, Bower, & Watsford, 2010; King, Hough, McGinnis, & Perkins, 2012; Tabuchi, Matsuo, & Hashizume, 2007). Furthermore, motion capture system usually been tested in lab based which required large space and cannot be tested on real field. Example of motion capture systems that been used are Qualisys Motion Capture (Crisco et al., 2002; Greenwald et al., 2001; Inkster et al., 2010; Tabuchi et al., 2007) and Vicon Motion System (Ae & Koike, 2011; Chang et al., 2011; King et al., 2012). Though using motion capture system to measure batting velocity is valid and reliable, this approaches are expensive, time consuming and impractical for coaches (Sharma, Agarwal, Sharma, & Dhuria, 2013; Wright, 2008).

Nowadays, Zepp Baseball has been used by coaches and athletes in their training and testing batting performance (batting velocity). However, there is no evidence on the reliability of this device in measuring different swing velocity. Therefore, the aims of this study were to assess: (1) the relationship of Zepp Baseball and Qualisys in measuring batting velocity, (2) intra-model reliability of Zepp Baseball device for measuring different swing velocities (medium and fast), (3) intra-model reliability of Zepp Baseball device for measuring swing velocity.

Methods

Participants

A female collegiate softball player (Height: 160cm, Weight: 57, Age: 26 years old) participated as a single subject in this study.

Equipment

The participant performed sixty trials of different bat swing velocity using Zepp Baseball device. Zepp Baseball was attached to the bat’s (DemaRini; 34inch length; 24Oz weight) knob using mount. It was designed to be very small (28 mm in length, 28 mm in width and 11 mm in height), light (7.7 g) and consists of an inertial measurement unit (IMU) 3X gyroscope – dual accelerometer. Figure 1 shows the Zepp Baseball sensor. A total of sixty swings was equally divided into two different velocities which are moderate; Vm (22.35m/s – 29.06m/s), and fast; Vf (31.29m/s – 38.00m/s). These velocities represent from the collegiate softball players (Szymanski, 2007). Before swing, Zepp Baseball was synched and calibrated (Figure 2). Subject warmed up for ten minutes doing stretching exercises and practicing dry swing using the same bat. When the subject was ready to swing, she stood comfortably and marked her swing position which is slightly behind the batting tee. Two markers was attached at the end of bat and at the knob of bat for simultaneously recording with Qualisys motion capture (Figure 3). Subject was requested to swing and hit the tee ball to the net with 30 seconds rest between swings. Furthermore, 15 minutes rest was given to the participant after each 10 swings made. Bat swing velocity was recorded for each sixty trials. The data from the device is transmitted to an iphone (4s) via Bluetooth (2.1). The iPhone synced with the Zepp Baseball and display the batting velocity result.

The bat swing velocity was recorded simultaneously with Qualisys motion capture system. Motion capture was considered the criterion standard in this instance. Eight Oqus 3+ infrared cameras were used, and captured full frames at 240Hz. One 14mm reflective marker was firmly taped to the top end of the bat (Figure 3). Calibration of the laboratory space on the test date yielded a RMS error for 3D reconstruction of 0.32mm. Magnitude of marker velocity was taken as bat end point velocity. Motion data was filtered using a low-pass Butterworth filter.

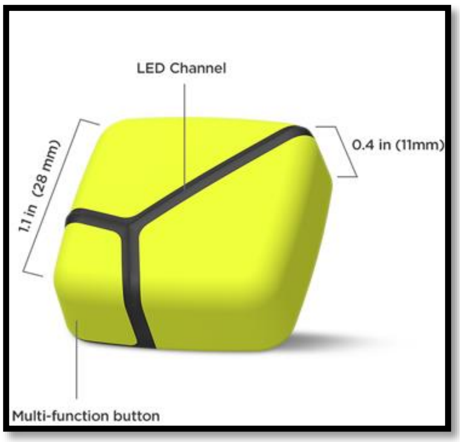

Figure : Zepp Baseball Sensor

Figure 2: Zepp Baseball was synched and calibrated

Figure 3: Two markers attached at the top and bottom of ba

Data Analysis

A Pearson Correlation was used to measure the relationship between Zepp Baseball and Qualisys motion capture on different batting velocities. Furthermore, Intra-class coefficient was used to measure the reliability of Zepp Baseball in measuring sixty trials of batting velocity. The statistical significant was set at an alpha level $p \leq .05$. All the data was analysed using the Statistical Package for Social Science version 21.0.

Results

Zepp Baseball does all of their analysis in English Units (miles per hour) while Qualisys motion capture in milimeter per second. This two results was converted to meter per seconds for all the trials. Analysis of the sixty swing data points using the Pearson Correlation summarized in Table 1 showed the summary of correlation for two types of velocities. Strong correlation were presented by moderate velocity (Vm r = .89) and moderate correlation for fast velocity (Vf r = .59). The Intraclass Correlation Coefficient (ICC) model 2 test indicates strong (Vm ICC = 0.89) agreement between Zepp Baseball and Qualisys for moderate velocity. While fair agreement was reported for fast velocity (Vf ICC = 0.37). Result on total of sixty swings showed high correlation (r = .96) with almost perfect agreement ICC = 0.93 between Zepp Baseball and Qualisys. This indicates that measuring batting velocity from Zepp Baseball and Qualisys have a very high level of agreement because they measure almost the same value.

Table 1: Correlation between Zepp and Qualisys (n = 30)

Velocities		**Zepp**
Moderate (25.7 ± 1.8 m/s)	Qualisys	$.89^{**}$
Fast (32.9 ± 2.5 m/s)	Qualisys	$.59^{**}$

Discussion

Technology in sports such as the usage of wearable global positioning has allowed sport scientists to understand the locomotor demands of various sports activities. Furthermore, microsensors (i.e. accelerometers, gyroscopes and magnetometers) embedded within the units also have the capability to detect sport-specific movements. These microsensors have been used in individual and team sports to detect sport-specific movements and to provide feedback on performance.

One of the fundamental roles of a coach is providing appropriate feedback to the athletes. Numerous benefits could be gain such as improving in physical conditioning (strength, rehabilitation, endurance), psychological performance and technique when coaches able to give real-time feedback to the athletes (Hunt & Parry, 2016; Strand, Benson, Buck, McGill, & Smith, 2014). Most of wearable devices has been developed to assist with providing some of this feedback to the athletes and this study succeed in indicated that Zepp Baseball is one of the reliable wearable sensor that able to monitor the bat swing velocities in softball. Recent study demonstrated moderate to strong reliability for Zepp Baseball in measuring different velocities. This was similar with previous study by Bailey, McInnis, and Batcher (2016) which also founded that there was high intra class correlation (ICC = 0.96) between Zepp Baseball and swing velocities.

The usage of wearable sensors was not only discovered in softball sport but also in other sports such as rugby (MinimaxXTM S4 device), Tennis (Zepp Tennis), Golf (Zepp Golf) and many more (Chambers, Gabbett, Cole, & Beard, 2015; Mahmoud, Othman, Abdelrasoul, Stergiou, & Katz, 2015; Strand et al., 2014). These sensors were compared with established video analysis and was found reliable to be use with ICC ranged from 0.89 to 0.99. With the availability of powerful computer chips and advances in battery miniaturization and performance, small, low powered MEMS inertial and other sensors, small wearable sensor devices were developed to record data for after-the-event feedback or also able to simultaneously record, analyse and provide real-time feedback on the activities performed.

In summary, the Zepp Baseball device in this study appeared to provide an acceptable reliable batting velocity result for different velocities in batting. This device can be used as one of tools to measure the changes occur in training regimen and research purposes.

Conclusion

Zepp Baseball was tested and proven reliable to be used effectively in detecting movement that are specific to batting in softball and baseball. This device can be used by both softball and baseball players in observing their batting velocity during training. This device also able to help them to see the changes of their batting speed from time to time and help coaches to improve the players' batting velocity. This device also can be used for the whole team because it's able to store the whole team member's batting record. Detection of sport-specific movements such as batting using microsensors (Zepp Baseball) potentially provides coaches with an alternate perspective of non-locomotor activities influencing sporting performance.

Acknowledgement

The authors would like to express their highest gratitude to University of Malaya Sport Centre for the usage of biomechanics lab, motion analysis equipment, and also motion analysis expertise. We were also grateful for the grant support from Research Management Institute (RMI): 600-RMI/MyRA 5/3/LESTARI (32/2016).

Reference

Ae, K., & Koike, S. (2011). *Kinetic Analysis of Each Hand in Baseball Batting Motion at Different Hitting Point Heights.* Paper presented at the ISBS-Conference Proceedings Archive.

Bailey, C. A., McInnis, T. C., & Batcher, J. J. (2016). Bat swing mechanical analysis with an inertial measurement unit: reliability and implications for athlete monitoring. *Journal of Trainology, 5*(2), 43-45.

Chambers, R., Gabbett, T. J., Cole, M. H., & Beard, A. (2015). The use of wearable microsensors to quantify sport-specific movements. *Sports Medicine, 45*(7), 1065-1081.

Chang, Y.-W., Hsieh, H.-M., Yang, S.-M., Chen, F.-Y., Lin, H.-W., & Wu, H.-W. (2011). *Comparison of Torso Twist Between Slap Hit and Ordinary Hit in Softball Batting.* Paper presented at the ISBS-Conference Proceedings Archive.

Crisco, J. J., Greenwald, R. M., Blume, J. D., & Penna, L. H. (2002). Batting performance of wood and metal baseball bats. *Medicine and Science in Sports and Exercise, 34*(10), 1675-1684.

Greenwald, R. M., Penna, L. H., & Crisco, J. J. (2001). Differences in batted ball speed with wood and aluminum baseball bats: a batting cage study. *Journal of Applied Biomechanics, 17*(3), 241-252.

Hughes, S. S., Lyons, B. C., & Mayo, J. J. (2004). Effect of grip strength and grip strengthening exercises on instantaneous bat velocity of collegiate baseball players. *The Journal of Strength & Conditioning Research, 18*(2), 298-301.

Hunt, D., & Parry, D. (2016). *The role of classification in the development of wearable coaching devices.* Paper presented at the The 13th australasian conference on mathematics and computers in sport.

Inkster, B., Murphy, A., Bower, R., & Watsford, M. (2010). Differences in the kinematics of the baseball swing between hitters of varying skill. *Journal of Science and Medicine in Sport, 12*, e12-e13.

King, K., Hough, J., McGinnis, R., & Perkins, N. (2012). A new technology for resolving the dynamics of a swinging bat. *Sports Engineering, 15*(1), 41-52.

Mahmoud, I., Othman, A. A. A., Abdelrasoul, E., Stergiou, P., & Katz, L. (2015). The Reliability of a Real Time Wearable Sensing Device to Measure Vertical Jump. *Procedia Engineering, 112*, 467-472.

Sharma, A., Agarwal, M., Sharma, A., & Dhuria, P. (2013). Motion capture process, techniques and applications. *Int. J. Recent Innov. Trends Comput. Commun, 1*, 251-257.

Strand, B., Benson, D., Buck, R., McGill, W., & Smith, D. (2014). The characteristics of coaching expertise. *The Virginia Journal, 35*(2), 4-7.

Szymanski, D. J. (2007). Collegiate Baseball In-Season Training. *Strength & Conditioning Journal, 29*(4), 68-80.

Szymanski, D. J., DeRenne, C., & Spaniol, F. (2009). Contributing factors for increased bat swing velocity. *The Journal of Strength & Conditioning Research*, *23*(4), 1338-1352.

Szymanski, D. J., McIntyre, J., Szymanski, J., Bradford, T., Schade, R., Madsen, N., & Pascoe, D. (2007). Effect of torso rotational strength on angular hip, angular shoulder, and linear bat velocities of high school baseball players. *The Journal of Strength & Conditioning Research, 21*(4), 1117-1125.

Tabuchi, N., Matsuo, T., & Hashizume, K. (2007). Bat speed, trajectory, and timing for collegiate baseball batters hitting a stationary ball. *Sports Biomechanics, 6*(1), 17-30.

Wilson, J. M., Miller, A. L., Szymanski, D. J., Duncan, N. M., Andersen, J. C., Alcantara, Z. G., . . . Bergman, C. J. (2012). Effects of various warm-up devices and rest period lengths on batting velocity and acceleration of intercollegiate baseball players. *The Journal of Strength & Conditioning Research, 26*(9), 2317-2323.

Wright, I. (2008). Motion capture in golf. *International Journal of Sports Science and Coaching, 3*(Supplement 1), 161-182.