MUSCLE ACTIVATION IN SOFTBALL SWING

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Abstract— Batting remains as one of the most challenging skills to master in softball and baseball sports. Coaches haveresearched various training to developed key of successful batting, but most of this research has been inadequate in attempting to describe basic muscle activation in the swing of softball batting. The purpose of this surface electromyographic study was to identify the activation of the right and left pectoralis major muscles (clavicular heads), triceps brachii muscles, biceps brachii muscles, deltoid muscles, latissimus dorsi muscles, external oblique muscles, rectus abdominus muscles, rectus femoris muscles, biceps femoris muscles, gastrocnemius muscles, and tibialis anterior muscles in the softball swing. The results obtained from the test showed the most activated muscles to the least activated musles in batting. Ten healthy collegiate female softball players participated in ten trials of hitting a stationary ball. Results showed that right rectus femoris muscle activated most (81.4% of MMT) while right middle deltoid muscle least activated in swing movement (38% of MMT).

Keywords— Electromyography, Muscles, Softball, Swing.

I. INTRODUCTION

Softball batting requires highly skilled movement because the batter has to decide when (temporal information) and where (spatial information) to hit the pitch ball. It is very crucial to master the skill of batting to hit due to the ability of pitchers in pitching vary styles (fastballs, breaking balls, and changeups). Several factors including the velocity of the bat swing, temporal and spatial accuracy in predicting ball-bat contact, and repeatability of the swing are related to hitting a home run and increasing the probability of a hit. A hitter generates bat speed by utilizing a kinetic link, where sequential recruitment pattern of muscles occurs, transferring momentum from large musculature to smaller adjacent muscles[1]. Before bat-ball impact, the batter must perform preparatory movements including shifting his body weight to the trailing (back) foot, stepping, landing, and shifting his weight to the front foot. To understand and clarify the mechanisms of this movement, multiple measurements such as bat velocity [2-4], movement kinematics/kinetics [1, 4], and ground reaction force (GRF)[5, 6]have been applied. In addition, surface electromyography (sEMG) has been used for analyzing softball batting. Only 1comprehensive studies have investigated the performance of batting using sEMG. Shaffer et al.[7], who recorded activities from 12 muscles in the upper and lower limbs and trunk, reported that skilled baseball batting relies on a coordinated transfer of muscle activity from the lower limbs to the trunk and finally to the upper limbs. This study set about answering “which muscles activated most and recruit more during hitting performance”. Knowledge of a more optimal muscle recruitment or sequencing pattern would be useful for junior players and beginners to improve batting performance. However, because there were many studies reported on baseball swing, this study focus solely on muscle activation during softball swing. We assumed that these data would be directly related to the recruitment of major muscles that similar with baseball bat swing.

II. DETAILS EXPERIMENTAL

In this study, we evaluated sEMG activity in batting and clarified the movement patterns with a video camera to understand the sequence of batting movement in softball. The subjects hit a ball that placed stationary on a batting tee which adjusted to their hip level at an indoor facility.

2.1 Subjects

The participants were 10 right-handed collegiate female players (age, 24.90±0.74 years; height, 156.00±1.05cm; weight, 52.30±1.83kg). All participants were injury free at the time of data collection. All softball players had collegiate-level experience and had played softball at least at University tournament. The participants performed the experiment in 2 different days.

One day for swing and another day for manual muscle test (MMT). The subjects were instructed to eat and drink water normally on the day of the experiment and 1 day before the experiment. In addition, they were told to abstain from strenuous exercise for 24 hours before the experiment, and to sleep normally the night before the experiment. All participants received a detailed explanation of the experimental procedures and risks of the research before recordings were taken. Written informed consent was obtained from all subjects.

2.2 Procedure

Throughout the sEMG data recording in this study, a wireless Myon 320 sEMG system (Fig. 1) by Myon AG was extensively used. It able to transmit a

maximum of 16 parallel channels of transmitter signals of up to a maximum range of 30 meters.

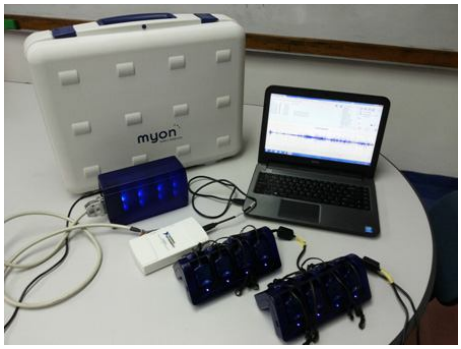

Fig.1. wireless Myon 320 sEMG system

Due to limited study on softball swing, specific muscle groups were chosen for this experiment based on past studies on baseball swing. Surface electromyography electrodes were attached bilaterally to the selected muscles such as pectoralis major (PM), triceps brachii (TB), biceps brachii (BB), anterior deltoid (AD), middle deltoid (MD), posterior deltoid (PD), rectus femoris (RF), biceps femoris (BF), gastrocnemius (G), latissimus dorsi (LD), external oblique (EO), rectus abdominus (RA), and tibialis anterior (TA). The protocol of electrode placement followed Criswell [8].

Areas to attach the electrodes on the participant's skin were shaved and cleaned with alcohol swab in order to geta good electrode-skin contact that allows a better sEMG recording and minimizes artifact noises [9, 10].Kendall Medi-Trace™ 530 type of electrodes (Ag/AgCl differential electrode) were used providing medical gradeadhesive with AQUA-TAC gel that is not only conductive, but also the adhesive can be removed without residue.Only two electrodes are required to be attached to a single Myon transmitter and therefore a total number of 32electrodes were attached on the participant's body at one session based on the chosen muscle groups. Due to the maximum muscles that can be recorded by Myon is eight, therefore this study separated into two sessions of bat swing. This is because, there are 13 muscles been investigated in this study. Every transmitter wassecured on the participant's body using masking tape as shown in Fig. 2..

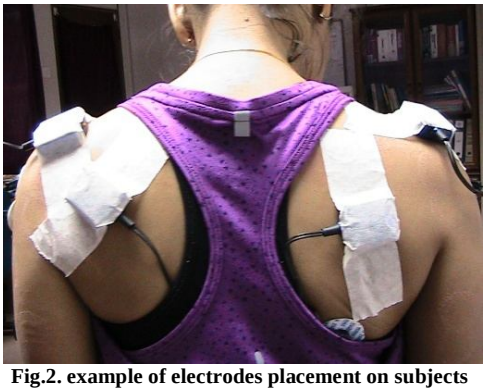

Fig.2. example of electrodes placement on subjects

Batting movement was also recorded at 240fps using a high-speed camera (Casio EX-ZR 800, Co., Ltd., Tokyo, Japan). Synchronization of the video images and the sEMG signals was accomplished by iphone apps (HIIT & Tabata) timer that simultaneously record both camera and electromyography reading. The participants were instructed to perform 10 batting trials for each session at an indoor facility. In swings trials, the participants had to hit a ball, which was stationary on batting tee. The batting tee level was adjusted to batter's hip and strike zone level. This study focused on total of 200 swing trials to clarify the movement patterns of swing with sEMG and a camera recording. A practice session with 5 trials was performed before the recordings for the batters to warm up and become familiar with the conditions. To avoid any effect of fatigue, after each trial, the batter have to wait for 10 seconds for next trial. All participants used the same bat (2014 BUSTOS (-10); Demarini, Hilsboro OR, USA; length = 34inch; weight = 24 Oz).

All procedures used in this study wereapproved by the Research Ethics Committee of the Research Management Institute (RMI), Universiti TeknologiMARA Malaysia (600-RMI (5/1/6/01)).

III. RESULTS AND DISCUSSION

A notch filter at 200Hz was used in filtering out artifact noise for all sEMG data recorded in this study. The signal was clearly shown in the power frequency spectrum of the sEMG raw data after being analyzed using FFT. This artifact noise was detected to be constantly present throughout the experiment from start to the end.

Sampling rate of the sEMG signal recording was set at 2000Hz using 20-450 Hz band pass filter. Powerfrequency spectrums of the raw data were first identified using Fast Fourier Transform (FFT) analysis pipeline inproEMG 2.0 to observe the characteristic of the artifact noises. Butterworth Low-Pass (450 Hz) and High-Pass (20Hz) filter were used before setting a notch filter at 200Hz with a steepness of 0.99. Root mean square (RMS) valuesof the filtered raw data were calculated to be used in subsequent analysis.

In the sEMG data for theright (R-PM, R-TB, R-BB, R-AD, R-MD, R-PD, R-RF, R-BF, R-G, R-LD, R-EO, R-RA, R-TA) and left (L-PM, L-TB, L-BB, L-AD, L-MD, L-PD, L-RF, L-BF, L-G, L-LD, L-EO, L-RA, L-TA) muscles of each participant, maximum voluntary isometric contraction (MVIC) data were obtained by asking the participants to perform maximal isometric contractions on the different day of test.

Participants were instructed to "push ashard as possible" for the 4-second period and were verballyencouraged to achieve maximum force at designated jointangles. Before the test, each participant performed adequate warm up exercises,

consisting of 2–3 submaximal contractions to become familiar with the test procedure. Isometric contraction was performed three time for each muscle, and all muscles were tested independently after a 1-minute rest period. Manual muscle testing protocols were implemented according to Hislop [11]. An MVIC value was determined as the highest mean sEMG amplitude observed during the MVIC task. These recording procedures were based on previous studies recording sEMG [12, 13].

To clarify the movement of selected muscles during batting, the movement was divided into 4 phases (Fig.3-5):

Fig.3. first phase (stance)

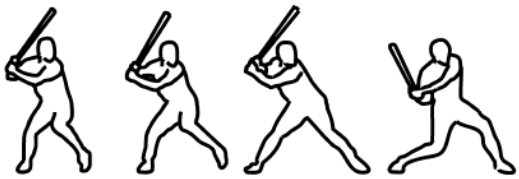

Fig.4. second phase (loading)

Fig.5. third and fourth phase (contact and follow through)

Stance: The phase before the shift in body weight with no specific movement.

Loading (initiation of the stepping motion of the left foot): The onset time was defined by the videotaped batting movement, when the left foot moved off the ground.

Contact (initiation of the bat swing movement until ball contact): The onset time was based on the videotaped movement, since the moment at which the left hand started to move down and forward until bat contact the ball.

Follow through: The phase that began after Impact.

The peak amplitude and latency of sEMG activity and the onset latency for each muscle, which were shown with %MVIC, were concluded among participants. The average peak amplitude values of all muscles for 10 trials were divided with MVIC to calculate the percentage of muscle activity. Statistical tests were performed using computer software (Microsoft Excel). Descriptive statistics reported in tables are reported as mean values and standard deviation.

Table 1: Percentage of Muscle Activated

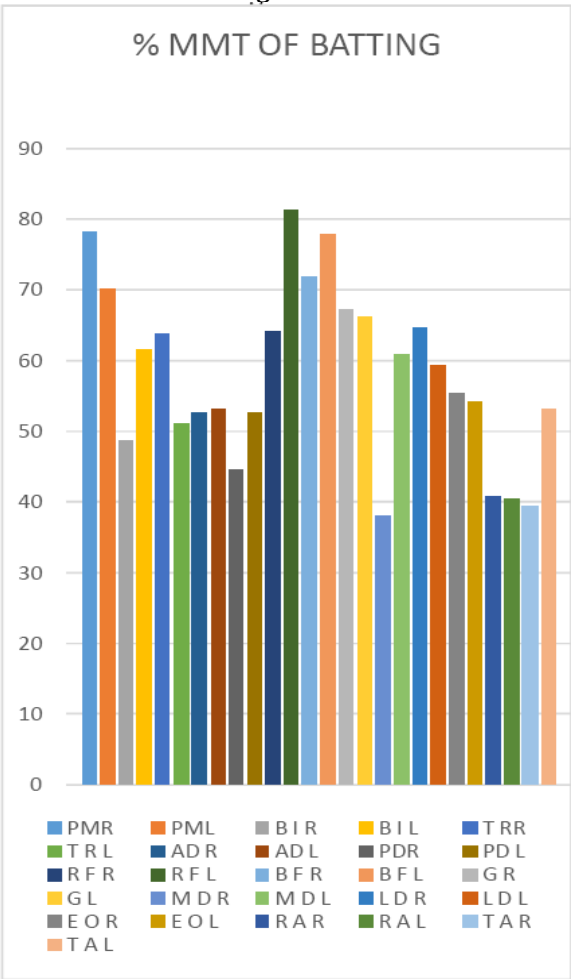

Table 1 showed overall result of muscle contraction (%) from a total of fifty swing records. Based on table below, L-RF showed greater contraction during batting (81.4%), followed by R-PM (78.2%), L-BF (77.8%), R-BF (72%), L-PM (70.2%), R-G (67.2%), L-G (66.2%), R-LD (64.6%), R-RF (64.2%), R-TB (63.8%), L-BB (61.6%), L-MD (60.8%), L-LD (59.2%), R-EO (55.4%), L-EO (54.2%), L-AD (53.2%), L-TA (53.2%), R-AD (52.6%), L-PD (52.6%), L-TB (51%), R-BB (48.6%), R-PD (44.6%), R-RA (40.8%), L-RA (40.4%), R-TA (39.4%), and R-MD (38%).

Hitting a ball with a round bat is considered one of the most difficult skills in sport[14]. Analyses of the movement patterns in softball are important because the results can be applied to actual training, and numerical expression of the timing in batting phases, such as waiting, shifting body weight, stepping, landing, and swing, is needed to assess the movements.

In this study, we investigated the activation of upper and lower extremity muscles during softball batting in female softball players. Identifying the muscle activation during the motion is important for understanding what role these muscles play throughout the batting sequence.

It was hypothesized that muscles involved during softball swing would be similar as in baseball swing. From recent study, it was proven that the most 10 activated muscles in batting are rectus femoris, pectoralis major, biceps femoris, gastrocnemius, latissimus dorsi, triceps brachii, biceps brachii, middle deltoids, external obliques, and anterior deltoids.

These findings was similar with study by Kitzman[15] when he tracked the bilateral function of the pectoralismajor, triceps brachii, and latissimus dorsi muscles in two professional players versustwo novices. However, limited results showed qualitatively that these muscles were engaged in theearly part of the swing while other muscles (not measured) took over in the later part of the swing to drive the bat through the hitting zone.

Shaffer and colleagues[7]provided the most comprehensive and quantitative view of muscle activity during the swing. Fine wire electrodes recorded EMG signals ofthe lower gluteus maximus of the back leg and the supraspinatus, triceps, posterior deltoid, and middle serratus anterior of the lead arm during the live swings of 18professional hitters. Surface electrodes were concurrently placed on the erector spinae and abdominal obliques, and vastus medialis obliques (VMOs), semimembranosus and biceps femoris of the back leg.

As with many of the kinematic and kinetic studies, the researchers divided the swing into four phases: “windup”, “pre-swing”, “swing” (later classified as early swing, middle swing, and late swing), and “follow-through”. The hamstring and gluteal muscles had high activity (as compared to values of a maximum muscle test, or MMT) during pre-swing and the early part of the swing phases, with values between 100% and 150% MMT. The VMOs contracted at roughly 95% to 110% MMT during the swing and follow-through.

In the trunk, erector spinae activity ranged from approximately 85% to 185% MMT during the pre-swing and swing phases, while the abdominal obliques were over 100% MMT during the pre-swing, swing, and follow through phases. In the upper body, the supraspinatus and serratus anterior muscles showed low activity (less than 40% MMT), while the posterior deltoid was most active (80% to 100% MMT) in the pre-swing and swing phases and the triceps was most active (over 90% MMT) in just the early part of the swing phase. It was concluded that the hamstring and gluteal muscles contribute to a stable base and drive the power thrust that uncoils the torso during the swing.

CONCLUSION

This study evaluated contractions of the muscles of the upper and lower extremities during sofball batting using sEMG and a high-speed video camera simultaneously in female softball players. The present findings concluded as follows:

1. Rectus femoris muscle activated most in batting (81.4% of MMT).
2. Middle deltoid muscle least activated in batting (38% of MMT).
3. Findings able to help coaches and condition professionals to understand the activation pattern of the selectedmuscles during batting skill and help teach the skill to junior players and novices.

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