行政院國家科學委員會專題研究計畫 成果報告

壘球推擊技巧之生物力學分析(第 2 年)
研究成果報告(完整版)

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公 開 資 訊 ：本計畫可公開查詢

中 華 民 國 100 年 10 月 31 日

中文摘要： 壘球推擊為左打者經常使用的打擊技巧，在打擊過程中，經由左腳的預先跨步，可拉近打者與一壘的距離，因而使成功踏上一壘的機會大增，因此，本研究的目的為比較壘球推擊與一般打擊在軀幹旋轉的生物力學上的差異。共有 10 位女性大學甲組壘球選手參與實驗，皆為左打者，利用 Vicon 三維動作分析系統，收集黏貼於身體上與球棒的反光標記，用以分析軀幹旋轉參數。結果發現，在打擊預備期時，推擊比一般打擊有較小的軀幹後旋產生，而在跟隨動作期時，一般打擊比推擊有較大的軀幹前旋，在擊球瞬間，推擊和一般打擊之間並無軀幹旋轉位置的顯著差異出現。結果顯示，使用此二種不同的打擊技巧，並不會影響打擊瞬間時軀幹相對於本壘板之位置。然而，對於影響打擊表現的因子而言，推擊的球棒線性速度與擊出球速，比一般打擊還要慢，同時，推擊的軀幹旋轉速度也比一般打擊來的小，因此，壘球選手選擇使用推擊技巧時，除了瞭解推擊時打者位置與一壘較近的優勢之外，也必須考量球速減低、限制預備期軀幹後旋與跟隨動作期軀幹前旋、以及軀幹旋轉速度變慢等運動生物力學上的改變，對打擊所造成的可能影響。

英文摘要： A slap hit is used for the left-handed batters who can get a running start before hitting the ball by using the left-side running slap. The purpose of this study was to compare the biomechanical difference of the torso twist between the slap and ordinary hit. Ten female left-handed college softball batters participated in this study. A VICON 612 motion analysis system was used to analyze the motion of the players. Surface reflective markers were placed on selective anatomical landmarks for each participant. Slap hits showed less backward rotation of the torso during wind-up phase while ordinary hits showed more forward rotation of the torso during follow-through phase. There was no significant difference between slap and ordinary hits at impact. The findings of this study suggested that torso rotational position at bat-ball contact was not affected by various hitting technique. Moreover, bat linear velocity, batted ball velocity and angular velocity of torso twist were decreased in slap hit compared to ordinary hit. The findings of this study suggested that in addition to the advantage of the hitter with more close position to first base, the possible disadvantage of slower batted ball velocity, reduced angular velocity of torso twist, the restricted torso backward twist in wind-up phase and limited torso forward twist in follow-through phase should be taken into consideration during performing the slap hit.

中文摘要

壘球推擊為左打者經常使用的打擊技巧，在打擊過程中，經由左腳的預先跨步，可拉近打者與一壘的距離，因而使成功踏上一壘的機會大增，因此，本研究的目的為比較壘球推擊與一般打擊在軀幹旋轉的生物力學上的差異。共有 10 位女性大學甲組壘球選手參與實驗，皆為左打者，利用 Vicon 三維動作分析系統，收集黏貼於身體上與球棒的反光標記，用以分析軀幹旋轉參數。結果發現，在打擊預備期時，推擊比一般打擊有較小的軀幹後旋產生，而在跟隨動作期時，一般打擊比推擊有較大的軀幹前旋，在擊球瞬間，推擊和一般打擊之間並無軀幹旋轉位置的顯著差異出現。結果顯示，使用此二種不同的打擊技巧，並不會影響打擊瞬間時軀幹相對於本壘板之位置。然而，對於影響打擊表現的因子而言，推擊的球棒線性速度與擊出球速，比一般打擊還要慢，同時，推擊的軀幹旋轉速度也比一般打擊來的小，因此，壘球選手選擇使用推擊技巧時，除了瞭解推擊時打者位置與一壘較近的優勢之外，也必須考量球速減低、限制預備期軀幹後旋與跟隨動作期軀幹前旋、以及軀幹旋轉速度變慢等運動生物力學上的改變，對打擊所造成的可能影響。

關鍵詞：推打、一般打擊、軀幹旋轉、擊出球速、球棒速度

Abstract

A slap hit is used for the left-handed batters who can get a running start before hitting the ball by using the left-side running slap. The purpose of this study was to compare the biomechanical difference of the torso twist between the slap and ordinary hit. Ten female left-handed college softball batters participated in this study. A VICON 612 motion analysis system was used to analyze the motion of the players. Surface reflective markers were placed on selective anatomical landmarks for each participant. Slap hits showed less backward rotation of the torso during wind-up phase while ordinary hits showed more forward rotation of the torso during follow-through phase. There was no significant difference between slap and ordinary hits at impact. The findings of this study suggested that torso rotational position at bat-ball contact was not affected by various hitting technique. Moreover, bat linear velocity, batted ball velocity and angular velocity of torso twist were decreased in slap hit compared to ordinary hit. The findings of this study suggested that in addition to the advantage of the hitter with more close position to first base, the possible disadvantage of slower batted ball velocity, reduced angular velocity of torso twist, the restricted torso backward twist in wind-up phase and limited torso forward twist in follow-through phase should be taken into consideration during performing the slap hit.

Keywords: slap hit, ordinary hit, torso twist, the batted ball velocity, bat velocity

Introduction

The excellence of sport performance has become one of the major goals of government policy in Taiwan. It is essential to longitudinally monitor the biomechanical characteristics of sports in order to reach the optimal performance. Softball is one of the sports that Taiwan has showed great success in international competitions (龍炳峰, 2006). Whilst the sport of softball has achieved worldwide popularity over the last 100 years, a consideration of the scientific principles underpinning softball is in its infancy (Flyger, et al., 2006).

Softball is a variation of baseball that uses a softer and larger ball, a smaller and lighter bat, and a smaller playing field. Various motor skills are associated with softball, such as pitching, batting and fielding. Excellent batting ability is one of the most important factors to win the competition. A powerful bat swing requires to be generated by using ground reaction force and transferring the force through biomechanical links of the motor segments in baseball hitting (Katsumata, 2007). Several biomechanical researches regarding ordinary (normal) hitting have been reported in previous studies. Tabuchi et al. (2007) found that the bat head was at maximum speed at impact when stationary balls of standard weight were used. Inkster et al. (2011) found that high-caliber hitters had a higher velocity (36.8 m/s) and lead elbow maximum angular velocity while low-caliber hitters had a lower velocity (33.8 m/s) and lead elbow maximum angular velocity. Nicholas et al. (2003) compared the bat kinematics difference between metal bats and wooden bats and found that metal bats produced a higher liner bat tip velocity than wooden bats because of lower swing moment of inertia in metal bats. There have been numerous baseball hitting studies published in literatures. In comparison, softball batting has received minimal attention in the sports science literature and a significantly smaller amount has been spent on the needs of the softball athlete (Welch et al., 1995).

Baseball/softball hitting is an open kinetic chain movement (Nicholls, 2003). The initiation of hitting is from the most proximal segment, the lower limbs, to the most distal part, the bat (Putman, 1993). In order, the connection between the proximal and distal segments should be well-coordinated to effectively accelerate the swing. A variety of batting techniques have been adopted in the course of a typical game in order to step to first base as quickly as possible. In addition to the ordinary hit, a slap hit is a unique technique legally and frequently used in softball game. A slap hit is used only for the left-handed batters who can get a running start before hitting the ball by using the left-side running slap. The batter is already several steps closer to the first base. Although slap hit seems to have its advantage in hitting competition, the biomechanical characteristics of softball slap hit is needed to be quantified to understand the kinematic difference from ordinary hit.

The torso is the kinetic linkage between the upper and lower limbs, and its sequential motion in batting has been considered to transfer power and generate synergy between the lower and upper limbs (Morishita, 2010). Welch et al. (1995) indicated that a hitter starts the swing with a weight shift toward the rear foot and development of torso twist. Escamilla et al (2009b) indicated that adult hitters maintained a more open pelvis position at lead foot off ground and maintained a more open upper torso position when the hands started to move forward and a more closed upper torso position at impact. Accordingly, investigating the hitting movement in term of torso twisting by focusing on the torso twist is a useful way for understanding the hitting kinematics. There have been lots of researches about baseball hitting in previous studies, very little is known about the twisting motion of the torso in slap hit techniques. Therefore, the purpose of this study was to compare the difference of the torso twist between the slap and ordinary hit. The hypothesis of this study was that there will be a significant difference between slap hit and ordinary hit, and the batted ball velocity and the linear bat velocity will be compensatory to the difference between two hitting techniques.

Methods

Participants

Ten female left-handed college softball batters participated in this study (age: 19.8±1.0 years; height: 160.7±3.2 cm; weight: 58.5±3.4 kg; hitting experience: 7.3±1.9 years). Before the experiment, the experimental procedure has been explained for each participant and the inform consent has been signed by each participant. The research protocol has been approved by the ethical committee of National Taiwan College of Physical Education.

Equipments and Protocol

A VICON 612 motion analysis system (Oxoford Metrics Limited.) with six digital cameras (250 Hz) was used to analyze the motion of the players. Surface reflective markers were placed on selective anatomical landmarks for each participant, including the acromion process, the spinal processe of the 8th thoracic spine and the anterior superior iliac spines. One surface marker was placed on the bat tip to measure the bat head velocity. The ball was wrapped with reflective paper to estimate the batted ball velocity. Each participant performed three trials of each hitting technique (ordinary hit and slap hit) from a batting tee.

Data Analysis

Softball batting consist of a wind-up, swing and follow-through phases (Fig 1). For the kinematic analysis, the swing motion in softball batting was divided into several events, including start of take back, right toe off, right toe on, swing start, impact and swing end (Tago, 2010). Slap hits had two additional instants during the wind-up phase, left toe off and left toe on, to prepare the players with anticipatory running start.

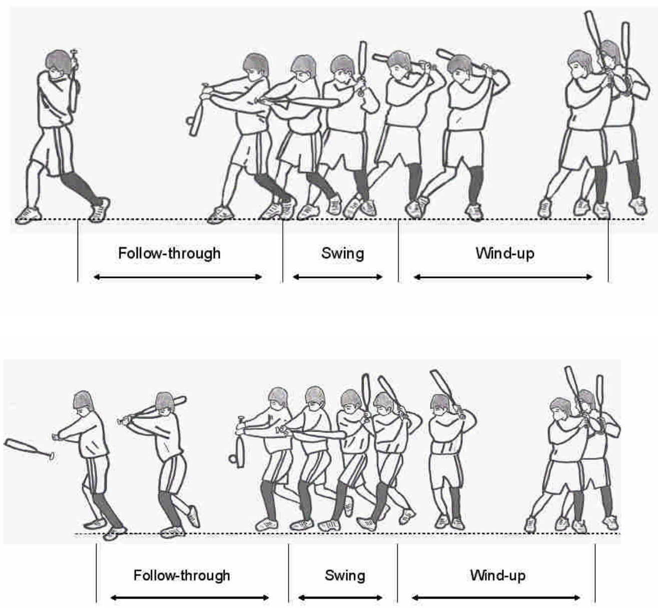

Figure 1: Ordinary hit (upper) and slap hit (lower).

The torso twist was defined as the angle between the direction of trunk segment in the frontal plane and the direction of the base toward the pitcher (Morishita, 2010). In this study, positive angle denoted a rotation to right (forward twist) and negative angle denoted a rotation to left (backward twist), while zero degree meant the torso was parallel to the direction of the base toward the pitcher. The batting time for each phase was recorded and the instant timing was measured and normalized as 100% of batting cycle.

Statistical Analysis

The testing variables were the batted ball velocity, the bat head velocity, the batting timing, the torso twist angle and its corresponding angular velocity at each specific instant in head, shoulder girdle, C7, T8, L5 and pelvis. Paired-t test was used to compare the difference for each analyzed parameter between ordinary hit and slap hit (SPSS, V13.0).

Results

Velocity and Timing

The batted ball velocity and the bat head velocity were shown in Table 1. There were significant difference between ordinary hit and slap hit ($p<0.005$). Ordinary hit had significantly faster batted ball velocity and bat head velocity than slap hit.

Table 1: Batted ball velocity and bat head velocity in ordinary hit and slap hit.

m/sec	Ordinary Hit	Slap Hit	P value
Batted ball velocity	19.94±3.06	16.81±3.88	0.003*
Bat head velocity	22.52±2.61	18.46±3.30	0.000*

*Significant difference ($p<0.05$).

Batting time and timing at each instant was shown in Table 2. Instant timing of right toe on had significant difference between ordinary hit and slap hit ($p<0.01$). Slap hit showed significantly faster right toe on than ordinary hit. No significant difference between ordinary hit and slap hit was found in batting time.

Table 2: Batting timing of each phase in ordinary hit and slap hit.

		Ordinary Hit	Slap Hit	P value
Time (ms)	Total	436.58±69.69	440.50±81.26	0.848
	Wind up	280.83±75.80	299.42±79.76	0.375
	Swing	65.33±14.75	14.92±115.03	0.152
	Follow through	90.42±37.78	126.17±113.30	0.296
Timing at each instant (%)	R toe off	38±13.7	31±12.1	0.159
	R toe on	59±9.1	48±10.3	0.007*
	Swing start	63±10.6	67±7.3	0.292
	Impact	79±9.1	71±25.9	0.291

*Significant difference ($p<0.05$).

Torso Twist Angle

<u>Angle at each Hitting Instant</u>

Head

The torso twist angles of the head in ordinary hit and slap hit were shown in Fig 2. Head position was not evidently changed until impact. Significant differences in head were found at the instants of the right toe off, right toe on and swing start ($p<0.05$). Slap hit showed more forward rotation than the ordinary hit during the mid-wind-up phase. However, there was no significant difference at impact.

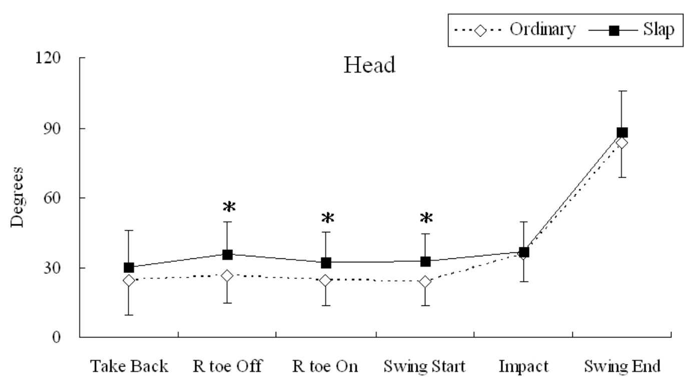

Figure 2: Torso twist angle of the head in ordinary hit and slap hit (* denoted paired t test, $p<0.05$).

Shoulder Girdle

The torso twist angles of the shoulder girdle in ordinary hit and slap hit were shown in Figure 3. Significant differences in shoulder girdle were found at the instants of the start of take back, right toe off, right toe on, swing start and swing end ($p<0.05$). Slap hit showed less torso backward rotation than the ordinary hit during the wind-up phase and less torso forward rotation during follow-through phase. However, there was no significant difference at impact.

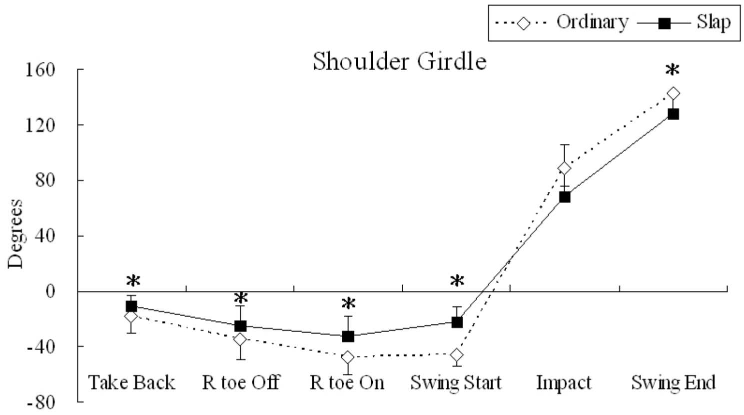

Figure 3: Torso twist angle of the shoulder girdle in ordinary hit and slap hit (* denoted paired t test, $p<0.05$).

C7

The torso twist angles of the C7 in ordinary hit and slap hit were shown in Figure 4. Significant differences in C7 were found at the instants of the start of take back, right toe off, right toe on, swing start and swing end ($p<0.05$). Slap hit showed less torso backward rotation than the ordinary hit during the wind-up phase and less torso forward rotation during follow-through phase. However, there was no significant difference at impact.

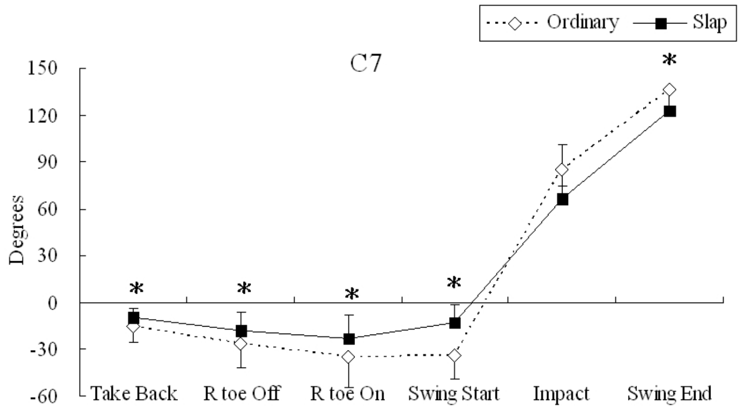

Figure 4: Torso twist angle of the C7 in ordinary hit and slap hit (* denoted paired t test, p<0.05).

T8

The torso twist angles of the T8 in ordinary hit and slap hit were shown in Figure 5. Significant differences in T8 were found at the instants of the start of take back, right toe off, right toe on and swing start (p<0.05). Slap hit showed less torso backward rotation than the ordinary hit during the wind-up phase. However, there was no significant difference at impact and swing end.

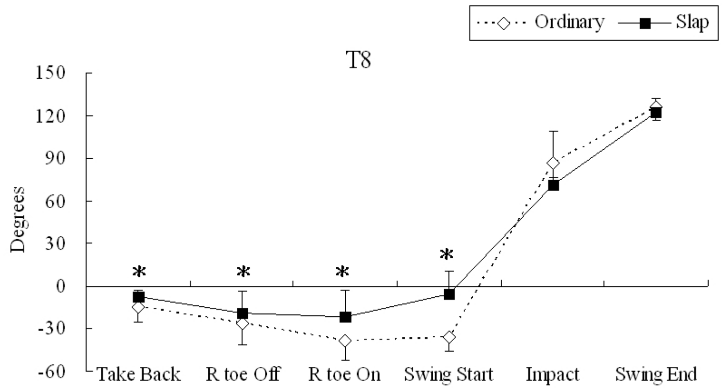

Figure 5: Torso twist angle of the T8 in ordinary hit and slap hit (* denoted paired t test, p<0.05).

L5

The torso twist angles of the L5 in ordinary hit and slap hit were shown in Figure 6. Significant differences in L5 were found at the instants of the start of take back, right toe off, right toe on and swing start (p<0.05). Slap hit showed less torso backward rotation than the ordinary hit during the wind-up phase. However, there was no significant difference at impact and follow-through phase.

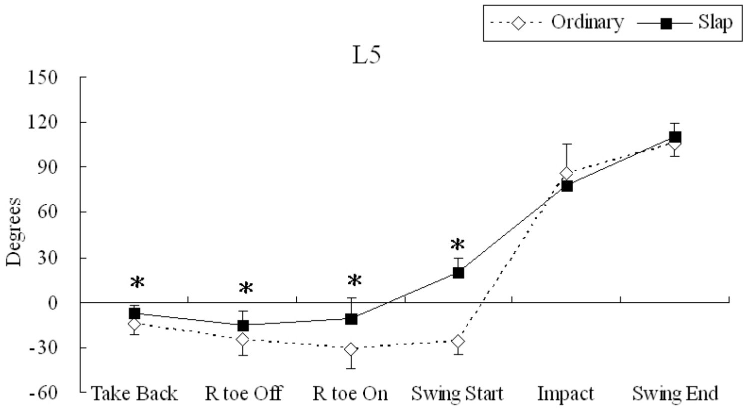

Figure 6: Torso twist angle of the L5 in ordinary hit and slap hit (* denoted paired t test, p<0.05).

Pelvis

The torso twist angles of the pelvis in ordinary hit and slap hit were shown in Figure 7. Significant differences in pelvis were found at the instants of the start of take back, right toe off, right toe on, swing start and swing end (p<0.05). Slap hit showed less torso backward rotation than the ordinary hit during the wind-up phase and more torso forward rotation during follow-through phase. However, there was no significant difference at impact.

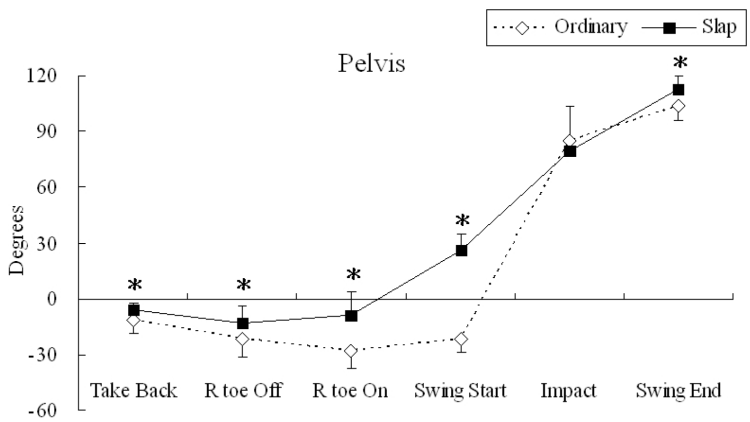

Figure 7: Torso twist angle of the pelvis in ordinary hit and slap hit (* denoted paired t test, p<0.05).

Peak Angle

Maximum forward torso twist angle in ordinary hit and slap hit was shown in Table 3. There was a significant difference between ordinary and slap hit in shoulder girdle, C7 and pelvis ($p<0.05$). Ordinary hit had significantly greater forward rotation in shoulder girdle and C7 than slap hit while slap hit had significantly greater forward rotation in pelvis than ordinary hit.

Table 3: Maximum forward torso twist angle in ordinary hit and slap hit. (* denoted paired t test, $p<0.05$)

(°)	Ordinary Hit	Slap Hit	P value
Head	83.76 ± 14.47	88.40 ± 17.06	0.476
Shoulder Girdle	143.27 ± 13.65	128.46 ± 13.03	0.026*
C7	136.41 ± 11.06	123.16 ± 13.00	0.040*
T8	127.39 ± 7.87	122.84 ± 9.70	0.248
L5	107.83 ± 9.59	111.66 ± 9.86	0.194
Pelvis	104.66 ± 6.64	113.21 ± 7.08	0.011*

Maximum backward torso twist angle in ordinary hit and slap hit was shown in Table 4. There was a significant difference between ordinary and slap hit in shoulder girdle, C7, T8, L5 and pelvis ($p<0.05$). Ordinary hit showed significantly more backward rotation than slap hit in all torso segments ($p<0.05$). However, no significance was found in head.

Table 4: Minimum torso twist angle in ordinary hit and slap hit. (* denoted paired t test, $p<0.05$)

(°)	Ordinary Hit	Slap Hit	P value
Head	20.17 ± 12.98	25.58 ± 14.59	0.165
Shoulder Girdle	-50.67 ± 10.44	-34.61 ± 14.41	0.001*
C7	-39.45 ± 12.54	-25.48 ± 13.20	0.005*
T8	-41.01 ± 11.25	-24.95 ± 16.57	0.000*
L5	-35.87 ± 9.45	-20.02 ± 11.44	0.000*
Pelvis	-32.70 ± 7.47	-17.23 ± 10.28	0.000*

ROM

Range of motion (maximum angle – minimum angle) in ordinary hit and slap hit was shown in Table 5. There was a significant difference between ordinary and slap hit in shoulder girdle, C7, T8 and L5 ($p<0.05$). Ordinary hit had significantly greater ROM than slap hit. No significance was found in head and pelvis.

Table 5: ROM of torso twist in ordinary hit and slap hit. (* denoted paired t test, $p<0.05$)

(°)	Ordinary Hit	Slap Hit	P value
Head	63.59 ± 19.46	62.82 ± 15.17	0.910
Shoulder Girdle	193.94 ± 20.31	163.07 ± 15.56	0.000*
C7	175.86 ± 14.93	148.63 ± 9.74	0.000*
T8	168.40 ± 16.17	147.79 ± 16.71	0.000*
L5	143.70 ± 15.19	131.68 ± 13.13	0.009*
Pelvis	137.36 ± 12.87	130.44 ± 11.82	0.068

Angular Velocity

<u>At Impact</u>

Angular velocity at impact in ordinary hit and slap hit was shown in Table 6. There was a significant difference on the angular velocity at impact for all segments, except L5 ($p<0.05$). Ordinary hit had significantly greater angular velocity than slap hit in head, shoulder girdle, C7, T8 and pelvis. It was obvious that angular velocity was getting faster from proximal (lower segment, pelvis; 255.2 m/s for ordinary hit; 204.6 m/s for slap hit) to distal (upper segment, shoulder girdle; 534.3 m/s for ordinary hit; 394.2 m/s for slap hit).

Table 6: Torso twist velocity at impact in ordinary hit and slap hit. (* denoted paired t test, $p<0.05$)

(°/s)	Ordinary Hit	Slap Hit	P value
Head	272.06 ± 181.27	157.75 ± 86.99	0.013*
Shoulder Girdle	534.27 ± 90.55	394.19 ± 74.74	0.000*
C7	493.82 ± 111.75	330.21 ± 60.60	0.000*
T8	518.02 ± 110.17	338.17 ± 75.08	0.001*
L5	276.97 ± 74.24	240.42 ± 76.75	0.063
Pelvis	255.22 ± 54.15	204.58 ± 53.38	0.005*

Peak Velocity

Maximum angular velocity of forward torso twist in ordinary hit and slap hit was shown in Table 7. There was a significant difference between ordinary hit and slap hit in shoulder girdle, C7, T8, L5 and pelvis ($p<0.05$). Ordinary hit had significantly greater angular velocity of forward rotation. However, no significant difference was found in head.

Table 7: Maximum torso twist velocity in ordinary hit and slap hit. (* denoted paired t test, $p<0.05$)

(°/s)	Ordinary Hit	Slap Hit	P value
Head	352.41 ± 224.37	268.96 ± 67.63	0.198
Shoulder Girdle	845.59 ± 124.41	616.26 ± 87.51	0.000*
C7	781.19 ± 150.86	575.57 ± 61.30	0.001*
T8	840.17 ± 116.37	573.62 ± 75.51	0.000*
L5	655.49 ± 147.70	366.06 ± 101.56	0.000*
Pelvis	588.68 ± 61.36	323.12 ± 64.56	0.000*

Timing at which maximum angular velocity of forward torso twist occurred in ordinary and slap hit was shown in Table 8. Zero denoted maximum angular velocity occurred at impact. Negative sign denoted maximum angular velocity occurred before impact while positive sign denoted maximum angular velocity occurred after impact. Maximum angular velocity occurred before impact in all torso segments except head. Significant difference was only found in shoulder girdle ($p<0.05$). Maximum angular velocity occurred earlier in slap hit (-17.6 ms) than in ordinary hit (-15.7 ms).

Table 8: Timing of max torso twist velocity in ordinary hit and slap hit (zero = the impact; negative = before impact; positive = after impact). (* denoted paired t test, $p<0.05$)

(ms)	Ordinary Hit	Slap Hit	P value
Head	9.90 ± 3.73	16.50 ± 46.53	0.658
Shoulder Girdle	-15.70 ± 2.79	-17.60 ± 2.50	0.025*
C7	-14.00 ± 7.07	-18.20 ± 1.87	0.060
T8	-13.80 ± 3.01	-16.00 ± 1.89	0.055
L5	-19.30 ± 4.62	-20.70 ± 14.98	0.786
Pelvis	-21.80 ± 2.74	-17.70 ± 5.79	0.054

Discussion

Slap Hit

This study investigated the torso kinematics of the slap hit. Slap hit is a softball hitting skill with unique hitting advantage. First, the batter stands in her standard hitting position so that she does not tip the defense. The slapper must be in position where crossover step will put her on the lines of the front inside corner of the box (Potter et al., 2007). To execute the slap, the hitter runs first and hits second. She starts to move when the ball leaves the pitcher's hand. She must not anticipate the release. If she starts too soon, she will have to stop moving to slap the ball or will be way out of the box (楊賢銘 et al., 2007). The first step is a small jab step with the right foot, either forward or backward. The jab step acts as a timing mechanism. The left foot crosses aggressively over the right foot directly to the pitcher. The left foot should land on the front line of the box on the inside corner. The right then opens slightly toward the pitcher.

A left-handed batter can get a running start before hitting the ball by using the left-side running slap. The lefty is already several steps closer to first base (Garman, 2001). Adding a running start puts tremendous pressure on the defense to make the play quickly. The play often moves the defense out of position as well. To be successful, the batter should have good speed and the ability to put the ball in play.

Bat Velocity

Bat swing velocity is a critical parameter of the baseball swing when identifying skill level and performance between hitters (Inkster et al. 2011). In this current study, batted ball velocity was approximately 15.7% less using a slap hit compared using an ordinary hit, while bat head velocity was approximately 18.0% less using a slap hit compared using an ordinary hit. Escamilla et al. (2009) investigated the bat (distal end) linear velocity at bat-ball contact in baseball hitting and the results showed 31±4 m/s in normal grip and 28±5 m/s in choke-up grip. Welch et al. (1995) quantified the maximum bat linear velocity (31±2 m/s) in baseball hitting. Inkster et al. (2011) measured the bat linear velocity in high-caliber hitters (36.8±3.1 m/s) and low-caliber hitters (33.8±

2.1 m/s). The velocity measured in previous studies (31-37 m/s) was higher than the velocity measured in this study (23 m/s) and it might be due to the different sports (baseball vs. softball) and different players (male vs. female).

Swing Timing

This study showed no significant difference on the time of each phase between slap hit and ordinary hit, implying that the early stance of the right lower limb would not affect the phase timing. However, slap hit (48% of hitting phase) showed significantly early right toe on than ordinary hit (59% of hitting phase). No other instant timing parameter was significantly different between two hitting skills. It was implied that the torso movement coordination of softball swing was quite close for these two hitting skills as a consequence of the similar temporal instant, such as right toe off, swing start and impact. Escamilla et al. (2009a) measured the time of each phase in baseball hitting. Based on Escamilla's definition of hitting phase, we re-calculated the phase time percentage for our data. In this study, ordinary softball hitting had the 51.22%, 9.76% and 39.02% for stride, transition and acceleration phase, respectively, while in Escamilla's study, baseball hitting had the 64.0%, 12.1% and 23.9% for stride, transition and acceleration phase, respectively. It was indicated that body coordination and movement strategy were different in baseball and softball hitting due to the various temporal instant.

Torso Twist Angle

For upper torso (shoulder girdle), from take back to swing start, the slap hit showed less backward rotation than the ordinary hit, indicating that the slap hit step forward with left leg during the wind-up phase would substantially influence or limit the torso twist backward. At the end of swing, more upper torso twist was present in the ordinary hit (more rotation to right). It would perhaps be the outcome of higher swing velocity.

The middle and lower torso (the thorax and pelvis), showed very similar twisting patterns. However, when examining the difference between the ordinary hit and the slap hit in the wind-up phase, the tendency of getting greater difference was observed between the upper torso and lower torso as well as from the early wind-up to late wind-up phases. At swing start, the lower torso in the slap hit already rotated toward the direction of pitcher (26° of forward rotation) while in the ordinary hit, the torso maintained a backward position (22° of backward rotation) to prepare the further quick forward rotation of trunk during the swing phase.

The restricted backward torso twist in the wind-up phase and the incomplete forward torso twist in the follow-through phase, especially in the upper torso, may be the cause of the limited bat swing acceleration in the slap hit. This possible disadvantage should be taken into consideration in softball batting when the batters using the slap hit, making the batter much closer to the first base.

A more closed position is assumed if the torso twist angle becomes less positive or more negative (Escamilla et al., 2009a & 2009b). A more open position is assumed if the torso twist angle becomes more positive. All torso segments showed open position at impact. No significant differences at impact were found in any torso segment. It was then clear that the torso position at bat-ball contact was not affected by various hitting techniques used prior to impact. Katsumata (2007) demonstrated that the timing of stepping with a front foot and shifting weight forward was modified relative to the pitch's speed but timing variability progressively reduced up to bat-ball contact. Thus, no matter what hitting skill is used or how fast the ball is pitched, the hitter's movement coordination is approaching consistent at impact.

In comparison with previous study, we found that our findings of torso twist angle were close to Welch's study (Table 9).

Table 9: Comparison of torso twist angle (°) between previous study and this study.

Segment	Study	Toe off	Toe On	Impact
Shoulder girdle	Welch (1995)	-30±14	-29±16	66±22
	This study	-34±15	-48±12	88±12
Pelvis	Welch (1995)	-18±7	4±17	83±9
	This study	-22±10	-22±7	85±9

<u>Timing from backward to forward rotation</u>

Head was always in the direction of pitcher before impact, corresponding to 25° and 33° of forward rotation in ordinary hit and slap hit, respectively, to allow the batters to focus on the pitcher and the pitching ball. The greatest forward rotation in head was found at swing end. The timing from backward to forward rotation in shoulder girdle, C7 and T8 was just subsequent to swing start in ordinary hit and slap hit. However, the timing from backward to forward rotation in L5 and pelvis was between right toe on and swing start in slap hit, while the timing from backward to forward rotation in L5 and pelvis was between swing start and impact in slap hit.

Velocity of Torso Twist

This study showed that ordinary hit had significantly greater angular velocity of torso twist than slap hit at each torso segment, from shoulder girdle to pelvis except head rotational velocity, ranging from 589 °/s to 846 °/s in ordinary hit and from 323 °/s to 616 °/s in slap hit. There was a trend that faster velocity occurred in upper torso (distal segment, shoulder girdle) while slower velocity occurred in lower torso (proximal segment, pelvis), indicating a segmental rotation found during softball hitting. Escamilla et al. (2009) measured the peak pelvis angular velocity (681 °/s) and peak upper torso angular velocity (850 °/s) in baseball hitting. Welch et al. (1995) measured the maximum hip rotational velocity (714±76 °/s) and maximum shoulder rotation velocity (937±102 °/s) in baseball hitting. Both above studies demonstrated quicker velocities than the velocities measured in this study. But both studies revealed the tendency that upper torso velocity was faster than lower torso velocity.

Instant of Bat-Ball Contact

Bat-ball contact is one of the most critical instant in baseball/softball hitting. Our comparison between ordinary hit and slap hit showed no significant difference on torso twist angles but significant differences on torso twist velocities (except L5). It was indicated that slap hit did not affect the torso twist angle but might influence or inhibit the torso twist velocity. Softball players performed these two hitting skills with the similar body coordination but with different performance outcome at impact.

Limitation of This Study

We collected swing motion of the softball hitters with a stationary ball in a motion laboratory using a batting tee. The ball pitched from the pitcher and the real field in stadium were not used in this study. It might be different from the real satiation of the completion or practice.

Conclusion

This study investigated the torso twist in the slap hit and ordinary hit. Slap hits showed less backward rotation of the torso during wind-up phase while ordinary hits showed more forward rotation of the torso during follow-through phase. There was no difference between slap and ordinary hits at impact. The findings of this study suggested that torso rotational position at bat-ball contact was not affected by various hitting technique. The restricted torso backward twist in wind-up phase and limited torso forward twist in follow-through phase should be taken into consideration during the slap hit. The numerous differences in kinematics and temporal parameters between ordinary hit and slap hit suggest that hitting mechanics are different between these two hitting skills.

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附件四

國科會補助專題研究計畫項下出席國際學術會議心得報告

日期：100 年 7 月 28 日

計畫編號	NSC 98－ 2410 － H －028 －003 －MY2		
計畫名稱	壘球推擊技巧之生物力學分析		
出國人員姓名	張怡雯	服務機構及職稱	國立臺灣體育學院 運動健康科學學系 副教授
會議時間	2011 年 06 月 27 日至 2011 年 07 月 01 日	會議地點	葡萄牙 波多 Porto, Portugal
會議名稱	2011年第二十九屆國際運動生物力學研討會 29th Conference of the International Society of Biomechanics in Sports		
發表論文題目	Comparison Of Torso Twist Between Slap Hit And Ordinary Hit In Softball Batting		

一、參加會議經過

國際運動生物力學年會暨學術研討會(International Society of Biomechanics in Sports, ISBS)，每一年都由世界各地會員國來主辦，ISBS 舉辦至今年 2011 年已經為第 29 屆了，真是相當具有代表性與歷史性的國際生物力學研討會。今年由歐洲最西方的國家-葡萄牙波多市的波多大學(University of Porto) 舉辦，會議日期為 2011 年 6 月 27 日至 7 月 1 日。

圖一：2011 年國際運動生物力學研討會標記(左)與波多大學校徽(右)。

由於臺灣並無直航飛機可以抵達葡萄牙波多，需要由其他國家來轉機，因此我們須轉機才能抵達。首先由高雄小港機場出發飛抵香港，再轉飛到達德國法蘭克福機場，入境歐洲之後，再繼續飛到葡萄牙波多，這超過 24 小時的長途旅程，著實令人覺得興奮

但又有些疲累。到達波多的國際機場時，已是當地時間半夜 12 點多，天色黑暗，路上荒涼，最後我們搭乘計程車去旅館。

圖二：波多市的街景，紅磚瓦屋頂為其特色，古色古香，和臺灣的透天厝有異曲同工之妙

隔天早上起來，在旅館附近一看，發現葡萄牙果然到處是古蹟，真是一個相當漂亮的城市，也是一個需要用心體會的歷史古都。下午我們便搭乘大會接駁車到達會場－波多大學的體育運動中心辦理報到，領取資料後便參加了下午的表面肌電圖工作坊 (Surface EMG workshop)，由 Delsys 講師主講，開始了一連五天研討會的序幕。晚上有開幕儀式和酒會，並有波多大學學生表演啦啦隊，相當精采，贏得大家熱烈的掌聲。

圖三：波多大學的學生表演啦啦隊，青春洋溢。

會議的第二天到第五天的早上 8 點半，大會都有接駁車將與會學者由旅館載到會場，相當方便。會議議程的安排，每天早上都有一場專題演講 (Keynote speaking)，皆是邀請世界級的運動生物力學大師來演講，相當精彩，接下來為口頭發表 (Oral presentation) 與海報發表 (Poster presentation)，參與學者都仔細聆聽，並有精闢的提問，真是令人收穫良多。中午大會並有提供午餐，皆為葡萄牙當地的傳統美食，雖然口味和臺灣食物不同，但也相當可口，尤其葡萄牙緊鄰大西洋，海鮮漁獲量相當豐富，品嘗當季的葡式海鮮風味，非常新鮮。

圖四：參加大地遊戲之分組競賽，中間為我們這組的小隊輔。

在會議第三天的下午為戶外行程 (Social tour)，大會安排了大地遊戲，將參加學者分組，一組 10 人左右，在波多市中心的風景名勝景點，以及許多的世界遺址 (World heritage)，讓大家回答週邊景點與古蹟的歷史問題，由於歷史文化內容深入，對於沒有深厚歐洲歷史背景的我們，要正確回答問題，還真的有一些吃力。中間並穿插了到餐廳品酒，品嚐歐洲頗富盛名的波多酒 (Porto wine)，並同時享用牛奶起司與羊奶起司。接著大會帶領大家參觀了知名多羅河畔 (river Douro) 歷史悠久的 Ferreira 製酒廠，引導人員細細解說，瞭解製酒過程的每一道繁複手續，也瞭解每一年氣溫雨量的不同，都會影響到葡萄結果的品質，所以只有特定年分的葡萄可以拿來製酒，也同時學到了一些葡萄製酒的知識。

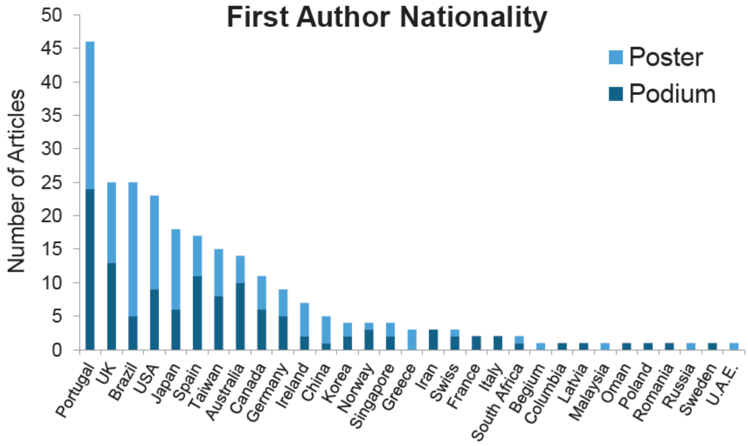
圖五：來自臺灣的學者們，於波多市多羅河畔酒廠品酒時合影。

會議的最後一天的晚上，照例有閉幕晚宴(Closing banquet)，這次是在一個古色古香的古蹟城堡中舉行，相當華麗璀燦。首先安排一段交響樂的演奏，接著入席，上菜時，配合前菜、沙拉、主餐、甜點，服務人員會適時變化不同的紅酒或白酒來作配合，果然是有歷史悠久品酒文化的波多城。現場同時有許多葡萄牙歌手的專業演唱表演，聲音非常優美動聽，最後當然是各項口頭報告及海報發表優等獎項的頒發與辛苦的與會工作人員的致謝，得獎者莫不喜悅不已。等到晚宴結束，大家相約明年澳洲墨爾本的 ISBS 2012 再見。

圖六：舉辦閉幕晚宴的古堡，中間為交響樂的精彩表演。

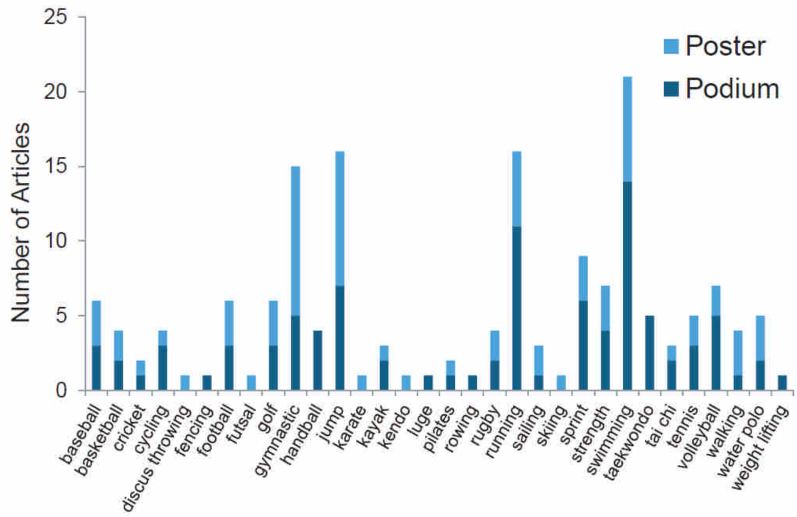
二、與會心得

此次參與會議的專家學者，來自世界各地，例如：地主國葡萄牙、英國、巴西、美國、日本、西班牙等，大會將投稿論文第一作者的國家數量作排序，臺灣排名第七，在整個排序上，算是相當前面的，也表示在臺灣的運動生物力學正蓬勃發展，希望能對於競技運動與休閒運動上，能有整體正面的影響，進而提高選手的運動表現。



圖七：此次會議所發表論文的第一作者國籍統計。

此次會議主題包羅萬象，舉凡世界性的運動項目，皆有不同國家的學者在研究，其中，投稿論文數量最多的是游泳，其次分別為跳躍、跑步、體操、短跑等。經由聆聽不同的場次，選擇不一樣的運動主題，可以對於不同的運動型式多所瞭解。



圖八：此次會議所發表論文的專項運動種類統計。

在這些不同的運動項目之中，我最感到有興趣的項目為跆拳道生物力學研究。由於跆拳道為我國在亞奧運中的重點奪牌項目，亦為臺灣年輕學童參與的運動中，經常學習的運動項目之一，在許多地方也都有跆拳道道館的設置，是一項相當普及的運動種類。希望經由運動生物力學的量化分析，可以更精進跆拳道選手的表現，使跆拳道專項技能能更充分發揮，最終以達到更優異的比賽成績為目的。以下為二篇跆拳道的生物力學論文的發表結果：

Kinematical Analysis of Five Different Kicks in Taekwondo

五種不同跆拳道踢擊的運動學分析

準確的時間與快速的動作是決定跆拳道比賽成功的重要因子，因此，本研究目的為確認哪些跆拳道的足部技巧可以在比賽中獲得最可能的成功，經由比較旋踢(round kick)、前下踢(front leg axe kick)、下壓(clench axe kick)、旋後跳踢(jump spin back kick)和旋後勾踢(jump hook back kick)五種在跆拳道裡最常用的踢擊技巧，分析反應時間、動作時間和總反應時間，共有八位甲組專項跆拳道選手參與此研究，利用三台 Casio HD 攝影機以 300 Hz 頻率去記錄運動學參數，並使用頭部和頸部模型作為目標。單因子變異數分析的統計結果顯示，雖然在反應時間並無差異，但在動作時間和總反應時間上，不同的技巧確實有顯著的不同($P<0.01$)。由此可知，在快速的比賽節奏下，應選擇動作時間最短暫迅速的踢擊技巧，才能有較佳的致勝機會。

Mechanical Analysis of the Roundhouse Kick According to the Stance Position. A Pilot Study.

不同站立位置的旋踢之力學分析 – 前測研究

跆拳道的踢擊表現受到站立位置的影響，本研究目的為分析在三種不同站立位置(0 ，45^{o}, 90^{o}) 下，旋踢的力學參數。共有兩位甲組跆拳道選手參與此研究，藉由兩塊測力板和八

台 3D 動作分析系統攝影機來測量力學參數，資料由 Visual 3D 軟體進行分析。選手在 0 與 45°位置的踢擊動作時間與總反應時間比 90°位置來的快速 ($P<0.05$)，而地面反作用力亦可應用於預測動作表現的變異，因此，對於選手而言，選擇在 0 與 45°的位置比在 90°位置更容易有較快速的總反應時間，因而能產生較優異的表現。

三、建議

在聆聽了多場的來自世界各地學者所發表的跆拳道運動生物力學的報告後，深深覺得獲益匪淺，如何經由分析各項跆拳道的變因，找出最有利的致勝關鍵，並與教練、選手搭配合作，統整各個影響因子，並實際應用於訓練與比賽場上，這還是目前有待大家思考與努力的方向，也希望經由科學性的研究量化，可以把臺灣的運動水準再上一層樓，達到世界性的頂尖層級，這也是作運動生物力學研究的最終目標。

圖九：此次會議所發表論文海報的合影。

在 2008 年曾參加過韓國首爾大學舉辦的 ISBS，及 2010 年於美國北密西根大學所舉辦的 ISBS，此次已經是第三次參加國際運動生物力學研討會。雖然都是同一個會議，但每一個地區或國家都有不同的文化特色，除了在會議中，運動生物力學的學術參與及討論是一樣的熱烈之外，經由不一樣的歷史語言的洗禮，還能深刻瞭解與尊重不同文化的特殊性。此次在歐洲歷史悠久的葡萄牙波多待了一週，發現他既有現代的文明，高水準的人民，高科技的大眾運輸系統，但隨處閒逛，市中心也好，郊區也好，卻發現處處是古蹟，也都保持的很完整，標記的非常清楚，古今交錯，但卻一點也不衝突。

圖十：小巷中斑駁的拱門與石牆，訴說著古老歲月的痕跡。

臺灣的運動生物力學學會將在 2013 年於台北舉辦第 31 屆的 ISBS，到時應該會有來自世界各地的學者專家與研究人員參加，除了邀請重量級的大師專題演講，安排各場次的口頭發表及海報發表外，介紹臺灣文化與歷史背景給各個國家的訪客知道，也是我們的使命之一，經由相關的活動安排導覽，希望到時可以讓大家認識臺灣、瞭解臺灣！

四、攜回資料名稱及內容

本次會議帶回的書面資料包括以下三大本：

1. **Programma and Abstracts Book**：包含會議資訊的介紹、議程和各學者所發表的論文摘要。
2. **Biomechanics in Sports 29**：包含各國學者在 2011 年 ISBS 所發表的論文內容，包含海報及口頭原創性論文的發表，都被收錄在葡萄牙體育學會當地所出版的期刊之中(葡萄牙運動科學期刊) Portuguese Journal of Sport Sciences, 11 (Suppl. 2), 2011。
3. **Applied Biomechanics in Sports**：2011 年 ISBS 研討會所邀請的專家學者主題演講內容，則收錄於此。

五、附錄

附錄一：大會議程

附錄二：參加研討會證明

附錄三：研討會論文封面

附錄四：發表之論文摘要

附錄五：發表之海報

附錄一：大會議程

General Programme

Hour	Monday 27/06	Tuesday 28/06	Wednesday 29/06	Thursday 30/06	Friday 01/07
8.30	Access to exhibition & Secretariat opening	Bus shuttle	Bus shuttle	Bus shuttle	Bus shuttle
9.00		Conference 2 G.-P. Brueggemann Biological tissue response to mechanical loading in impact sports	Conference 4 Mark King Computer simulation modelling in Sports Biomechanics	Conference 5 Walter Herzog Understanding muscle properties in sports performance optimization	Conference 7 Paavo Komi Identification of stretch-shortening cycles (SSC) in different sports
10.00		Parallel sessions (1 & 2) Applied Session: Biomechanical Modelling (room)	Parallel sessions (8 to 10)	Parallel sessions (11 to 13)	Parallel sessions (19 to 21)
11.30		Coffee-break	Coffee-break	Coffee-break	Coffee-break
12.00		Poster sessions (1 to 4)	Poster sessions (5 to 7)	Poster sessions (8 to 10)	Poster sessions (11 to 13)
13.00		Lunch & An. sport act.	Lunch & An. sport act.	Lunch & An. sport act.	Lunch & An. sport act.
14.30	Bus shuttle	Conference 3 Carlo de Luca Control of motor units during voluntary isometric force-production: implications for exercise	Social tour	Conference 6 Bruce Elliot The player development pathway: a biomechanical perspective	Conference 8 2010 NIA winner Anne Richter Specific issues of vertical jumps as fundamental performance diagnostics tools
15.00	ISBS Committee Pre-Conference Meeting				
15.30	DELSYS EMG Workshop (room 1)	Parallel sessions (3 to 5) Applied Session: Track & Field – Jumps (indoor track)		Parallel sessions (14 & 15) Applied Session: Swimming Biophysics (room)	New Investigator Award Finalists 2011
16.15					Coffee-break
16.45					ISBS Annual General Meeting
17.00	Opening ceremony	Coffee-break		Coffee-break	
17.30		Parallel sessions (6 & 7) Applied Session: Track & Field – Jumps (room)		Parallel sessions (16 to 18) Applied Session: Swimming Biophysics (swimming pool)	
18.00	Opening Conference 1 Youlian Hong The Geoffrey Dyson Lect.: Tai Chi: movement characteristics and prevention of falls				Happy-hour / ISBS Committee Post-Conference Meeting
19.00	Port of Honour	Happy-hour		Happy-hour	Bus shuttle
20.00	Bus shuttle			Bus shuttle	Transport to banquet
21.00		DELSYS Barbecue			Closing banquet
22.00					
23.00		Bus shuttle			
24.00					Bus shuttle

附錄二：參加研討會證明

ISBS 2011
PORTO PORTUGAL

Certificate of atendancy

This is to certificate that

Yi – Wen Chang

participated at the ISBS 2011 Conference
(Porto, June 27th to July 1st) as:

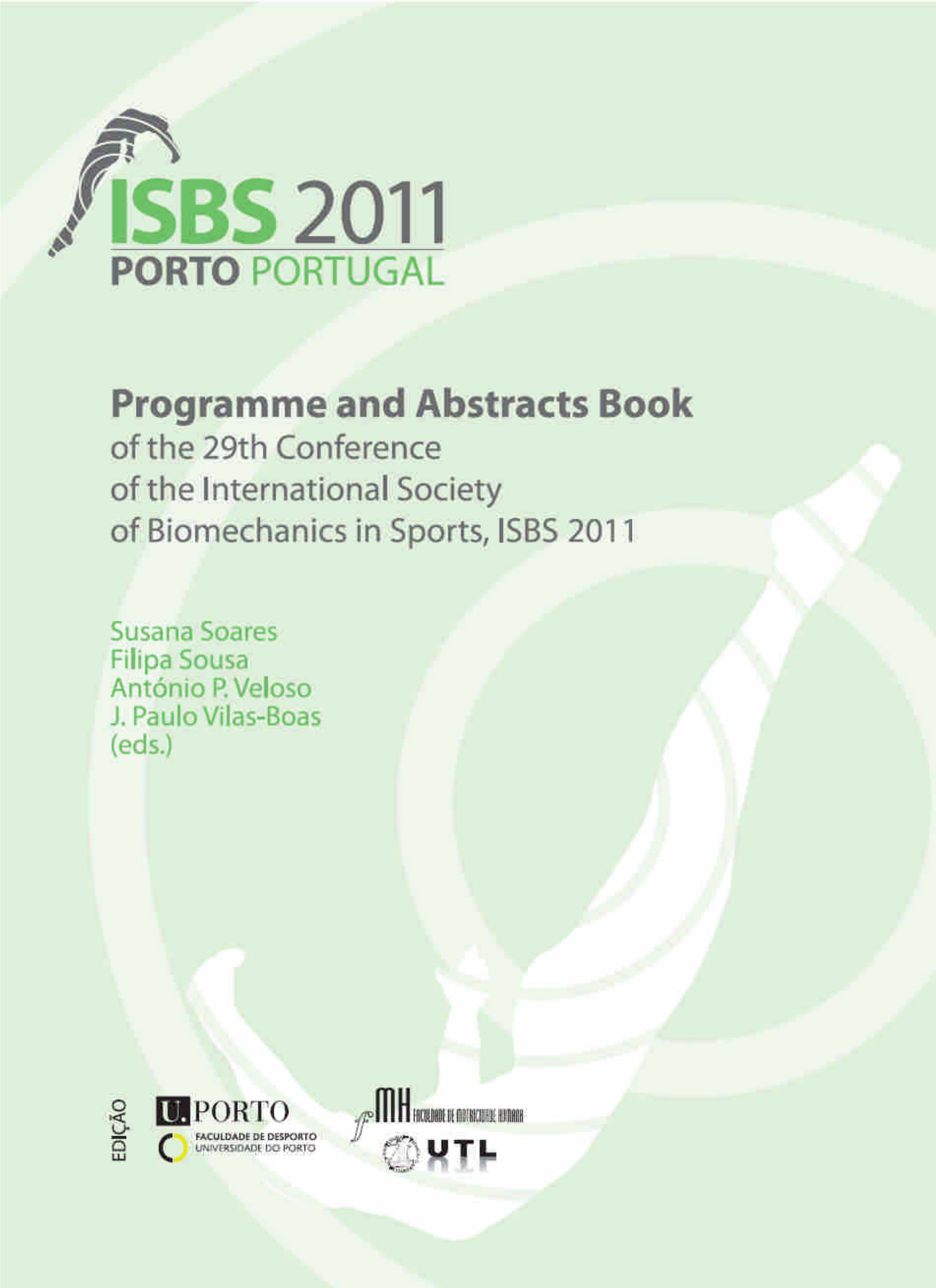
- Invited Speaker
- Chairperson
- Member of the Scientific Board
- X Author of a Poster Presentation
- Regular participant
- Author of a podium presentation
- Member of the Organizing Committee
- X Workshop or Applied Session Participant
- Commercial Exhibitor
- Volunteer
- Sponsor

Porto, July 1st 2011

J. Paulo Vilas-Boas
(FADEUP's Chairman of the Conference)

António Veloso
(FMH-UTL's Chairman of the Conference)

附錄三：研討會論文封面


ISBS 2011
PORTO PORTUGAL
Programme and Abstracts Book
of the 29th Conference
of the International Society
of Biomechanics in Sports, ISBS 2011
Susana Soares
Filipa Sousa
António P. Veloso
J. Paulo Vilas-Boas
(eds.)
EDIÇÃO
U.PORTO
FACULDADE DE DESPORTO
UNIVERSIDADE DO PORTO
MH
UTL

附錄四：發表之摘要

Vilas-Boas, Machado, Kim, Veloso (eds.)
Biomechanics in Sports 29

Portuguese Journal of Sport Sciences
11 (Suppl. 2), 2011

COMPARISON OF TORSO TWIST BETWEEN SLAP HIT AND ORDINARY HIT IN SOFTBALL BATTING

Yi-Wen Chang[1], Hsiu-Mei Hsieh[1], Shien-Ming Yang[2], Feng-Yin Chen[2] , Hua-Wei Lin[2] and Hong-Wen Wu[3]

Department of Exercise and Health Science[1], Department of Ball Sports[2], Department of Physical Education[3]
National Taiwan College of Physical Education, Taichung, Taiwan

Softball batters take advantage of slap hit, by positioning the batters much closer to the first base. The purpose of this study was to compare the difference of torso twist between a slap hit and an ordinary hit in softball batting. Ten female college softball batters performed slap hits and ordinary hits. Reflective markers were placed on specific landmarks for each subject and VICON motion analysis system was used to record the hits. Slap hits showed less backward rotation during the torso wind-up phase while ordinary hit showed more forward rotation during the torso follow-through phase. No difference on trunk rotation was found at impact. The findings of this study suggested that the restricted backward torso twist during the wind-up phase and the limited forward torso twist during the follow-through phase should be taken into consideration in slap hits.

KEY WORDS: shoulder girdle, thorax, pelvis.

INTRODUCTION: Various motor skills are associated with softball, such as pitching, batting and fielding. Excellent batting ability is one of the most important factors to win the competition. A variety of batting techniques have been adopted in the course of a typical game in order to step to first base as quickly as possible. In addition to the ordinary hit, a slap hit is a unique technique frequently used in softball batting. A slap hit is used only for the left-handed batters who can get a running start before hitting the ball by using the left-side running slap. The batter is already several steps closer to the first base. The torso is the kinetic linkage between the upper and lower limbs, and its sequential motion in batting has been considered to transfer power and generate synergy between the lower and upper limbs (Morishita, 2010). However, very little research has been conducted to study the twisting motion of the torso in various softball batting techniques. Therefore, the purpose of this study was to compare the difference of the torso twist between the slap and ordinary hits.

METHODS: Ten female left-handed college softball batters participated in this study (age: 19.8±1.0 years; height: 160.7±3.2 cm; weight: 58.5±3.4 kg; hitting experience: 7.3±1.9 years). A VICON 612 motion analysis system (Oxoford Metrics Limited.) with six digital cameras (250 Hz) was used to analyze the motion of the players. Surface reflective markers were placed on selective anatomical landmarks for each participant, including the acromion process, the spinal processe of the 8^{th} thoracic spine and the anterior superior iliac spines. Each participant performed three trials of each hitting technique from a batting tee.
Softball batting consist of a wind-up, swing and follow-through phases (Fig 1). For the kinematic analysis, the swing motion in softball batting was divided into several events, including start of take back, right toe off, right toe on, swing start, impact and swing end (Tago, 2010). Slap hits had two additional instants during the wind-up phase, left toe off and left toe on, to prepare the players with anticipatory running start. The torso twist was defined as the angle between the direction of trunk segment in the frontal plane and the direction of the base toward the pitcher (Morishita, 2010). In this study, positive angle denoted a rotation to right (forward twist) and negative angle denoted a rotation to left (backward twist), while zero degree meant the torso was parallel to the direction of the base toward the pitcher. Paired-t test was used to compare the difference between ordinary hits and slap hits (SPSS, V13.0). The testing variables were the torso twist angles at each specific batting instant in shoulder girdle, thorax and pelvis.

Portuguese Journal of Sport Sciences
11 (Suppl. 2), 2011

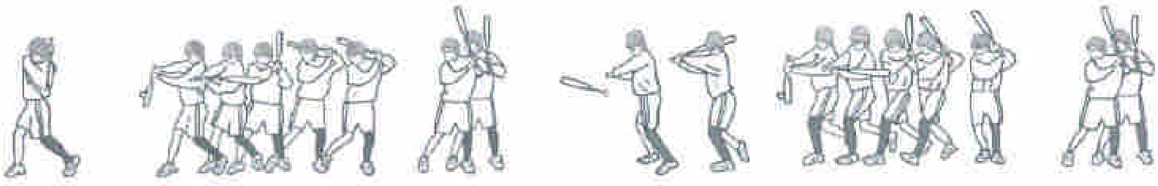


Figure 1: Ordinary hit (left) and slap hit (right).

RESULTS: The torso twist angles in ordinary and slap hits are shown in Fig 2. Significant differences in torso twist (from shoulder girdle to pelvis) were found at the instants of the start of take back, right toe off, right toe on, swing start and swing end ($p<0.05$). Slap hits showed less torso backward rotation than the ordinary hit during the wind-up phase. However, there was no significant difference at impact in all torso segments.

DISCUSSION: For upper torso (shoulder girdle), from take back to swing start, the slap hit showed less backward rotation than the ordinary hit, indicating that the slap hit step forward with left leg during the wind-up phase would substantially influence or limit the torso twist backward. At the end of swing, more upper torso twist was present in the ordinary hit (more rotation to right). It would perhaps be the outcome of higher swing velocity.

The middle and lower torso (the thorax and pelvis), showed very similar twisting patterns. However, when examining the difference between the ordinary hit and the slap hit in the wind-up phase, the tendency of getting greater difference was observed between the upper torso and lower torso as well as from the early wind-up to late wind-up phases. At swing start, the lower torso in the slap hit already rotated toward the direction of pitcher (26° of forward rotation) while in the ordinary hit, the torso maintained a backward position (22° of backward rotation) to prepare the further quick forward rotation of trunk during the swing phase.

The restricted backward torso twist in the wind-up phase and the incomplete forward torso twist in the follow-through phase, especially in the upper torso, may be the cause of the limited bat swing acceleration in the slap hit. This possible disadvantage should be taken into consideration in softball batting when the batters using the slap hit, making the batter much closer to the first base.

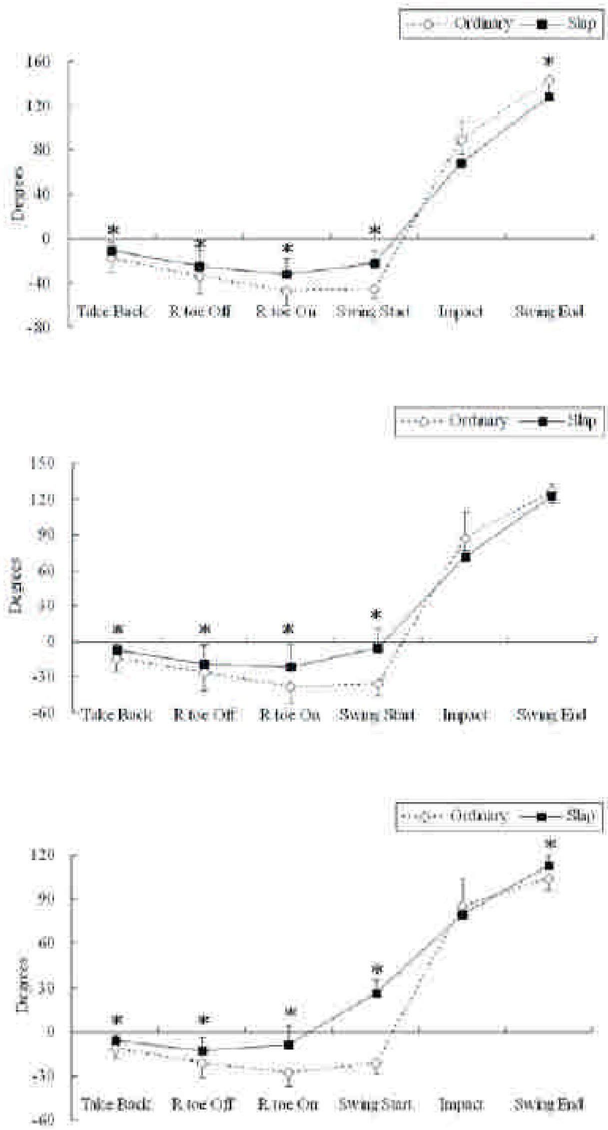


Figure 2: Torso twist angles in shoulder girdle (upper), thorax (middle), and pelvis (lower).
* denoted statistical significance (paired-t test, $p<0.05$).

No significant differences at impact were found in any torso segments. It was clear that the torso position at bat-ball contact was not affected by various hitting techniques used prior to impact.

CONCLUSION: This study investigated the torso twist in the slap hit and ordinary hit. Slap hits showed less backward rotation of the torso during wind-up phase while ordinary hits showed more forward rotation of the torso during follow-through phase. There was no difference between slap and ordinary hits at impact. The findings of this study suggested that torso rotational position at bat-ball contact was not affected by various hitting technique. The restricted torso backward twist in wind-up phase and limited torso forward twist in follow-through phase should be taken into consideration during the slap hit.

REFERENCES:

Morishita, Y., Tanai, T., & Hirano, Y. (2010). A new approach for assessing kinematics of torso twist in baseball batting: a preliminary report. XXVIII ISBS proceeding, 517-518.

Tago, T., Ae, M., Tsuchioka, D., Ishii, N., & Wada, T. (2010). Adjustment of the lower limb motion at different impact heights in baseball batting. XXVIII ISBS proceeding, 686-689.

Acknowledgement

The authors would like thank the supports from the National Science Council (NSC98-2410-H-028-003-MY2) and National Taiwan College of Physical Education (98DG000103), Taiwan.

附錄五：發表之海報

COMPARISON OF TORSO TWIST BETWEEN SLAP HIT AND ORDINARY HIT IN SOFTBALL BATTING

Yi-Wen Chang[1], Hsiu-Mei Hsieh[1], Shien-Ming Yang[2], Feng-Yin Chen[2], Hua-Wei Lin[2], and Hong-Wen Wu[3]
Department of Exercise and Health Science[1], Department of Ball Sports[2], Department of Physical Education[3]
National Taiwan College of Physical Education, Taichung, Taiwan

Introduction

- Excellent batting ability is one of the most important factors to win the competition. A variety of batting techniques have been adopted in the course of a typical game in order to step to first base as quickly as possible. A slap hit is used only for the left-handed batters who can get a running start before hitting the ball by using the left-side running slap. The batter is already several steps closer to the first base. The torso is the kinetic linkage between the upper and lower limbs, and its sequential motion in batting has been considered to transfer power and generate synergy between the lower and upper limbs (Morishita, 2010). However, very little research has been conducted to study the twisting motion of the torso in various batting techniques. Therefore, the purpose of this study was to compare the difference of the torso twist between the slap and ordinary hits.

Methods

- Ten female left-handed college softball batters participated in this study (age: 19.8±1.0 years; height: 160.7±3.2 cm; weight: 58.5±3.4 kg; hitting experience: 7.3±1.9 years). A VICON 612 motion analysis system with six cameras (250 Hz) was used to analyze the motion of the players. Surface reflective markers were placed on selective anatomical landmarks, including the acromion process, the spinal processe of the 8th thoracic spine and the anterior superior iliac spines. Each participant performed 3 trials of each hitting technique from a batting tee.
- Softball batting consist of a wind-up, swing and follow-through phases (Fig 1). The swing motion in softball batting was divided into several events, including start of take back, right toe off, right toe on, swing start, impact and swing end (Tago, 2010). Slap hits had two additional instants during the wind-up phase, left toe off and left toe on, to prepare the players with anticipatory running start.
- The torso twist was defined as the angle between the direction of trunk segment in the frontal plane and the direction of the base toward the pitcher (Morishita, 2010). Positive angle denoted a rotation to right (forward twist) and negative angle denoted a rotation to left (backward twist), while zero degree meant the torso was parallel to the direction of the base toward the pitcher. Paired-t test was used to compare the difference between ordinary hits and slap hits (SPSS, V13.0).

Results

- Significant differences in torso twist were found at the instants of the start of take back, right toe off, right toe on, swing start and swing end ($p<.05$, Fig 2).
- Slap hits showed less torso backward rotation than the ordinary hit during the wind-up phase. There was no significant difference at impact.

Discussion

- For upper torso, the slap hit showed less backward rotation than the ordinary hit, indicating that the slap hit step forward during the wind-up phase would substantially limit the torso twist backward. The middle and lower torso showed very similar twisting patterns.
- The tendency of getting greater difference was observed between the upper torso and lower torso as well as from the early wind-up to late wind-up phases.
- At swing start, the lower torso in the slap hit already rotated toward the direction of pitcher (26° of forward rotation) while the torso maintained a backward position (22° of backward rotation) in the ordinary hit.
- The restricted backward torso twist in the wind-up phase and the incomplete forward torso twist in the follow-through phase, especially in the upper torso, may be the cause of the limited bat swing acceleration in the slap hit. This possible disadvantage should be taken into consideration when the batters using the slap hit, making the batter much closer to the first base.

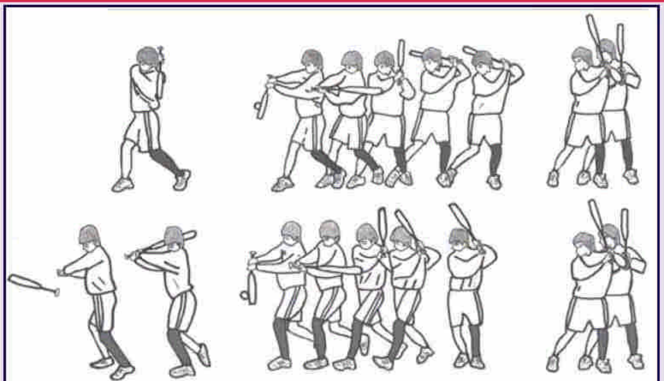


Figure 1: Ordinary hit (up) and slap hit (down).

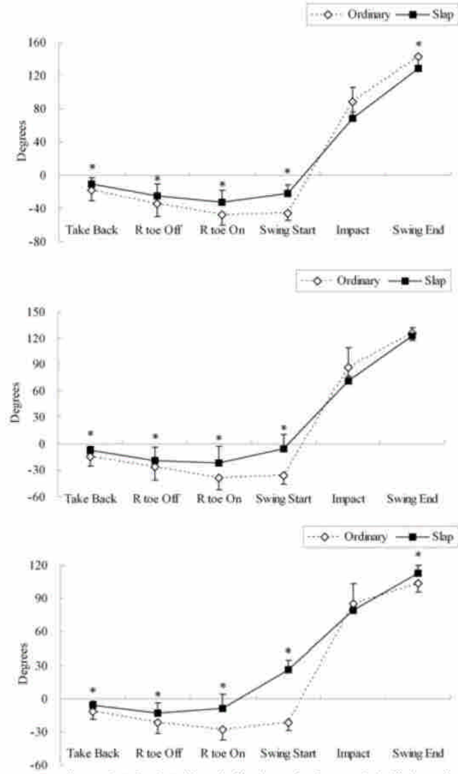


Fig2: Torso twist angles in shoulder girdle (upper), thorax (middle), and pelvis (lower). * denoted statistical significance (paired-t test, $p<0.05$).

Conclusion

- Slap hits showed less backward rotation of the torso during wind-up phase while ordinary hits showed more forward rotation of the torso during follow-through phase. There was no difference between slap and ordinary hits at impact. This study suggested that torso rotational position at bat-ball contact was not affected by various hitting technique. The restricted torso backward twist in wind-up phase and limited torso forward twist in follow-through phase should be taken into consideration during the slap hit.

References

Morishita, Tanai, Hirano (2010). A new approach for assessing kinematics of torso twist in baseball batting: a preliminary report. XXVIII ISBS processing, 517-518.

Tago, Ae, Tsuchioka, Ishii, Wada (2010). Adjustment of the lower limb motion at different impact heights in baseball batting. XXVIII ISBS proceeding, 686-689.

Acknowledgement

This study was supported by the National Science Council (NSC98-2410-H-028-003-MY2) and National Taiwan College of Physical Education (98DG000103), Taiwan.

P13.2

國科會補助計畫衍生研發成果推廣資料表

日期:2011/10/26

<table>
<tr><td rowspan="3">國科會補助計畫</td><td>計畫名稱: 壘球推擊技巧之生物力學分析</td></tr>
<tr><td>計畫主持人: 張怡雯</td></tr>
<tr><td>計畫編號: 98-2410-H-028-003-MY2　　　　學門領域: 運動生物力學</td></tr>
<tr><td colspan="2">無研發成果推廣資料</td></tr>
</table>

98 年度專題研究計畫研究成果彙整表

計畫主持人：張怡雯	計畫編號：98-2410-H-028-003-MY2
計畫名稱：壘球推擊技巧之生物力學分析	

成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	1	1	100%		
國外	論文著作	期刊論文	0	2	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	3	3	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)	無

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以 100 字為限）

□實驗失敗

□因故實驗中斷

□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文：□已發表 □未發表之文稿 ■撰寫中 □無

專利：□已獲得 □申請中 ■無

技轉：□已技轉 □洽談中 ■無

其他：（以 100 字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

本研究主要探討壘球推擊技巧與一般打擊在生物力學方面的異同，以量化在打擊動作分析上的各項變數。推擊技巧主要指的是，在壘球打擊過程中，在擊球之前，已預先跨出一步，由於壘包的方向，這種打擊技巧只適合左打者，使打者具有更靠近一壘壘包的優勢。然而，在其他的力學參數上，推擊是否也和一般打擊一樣，具有好的身體肢段連結與協調，同時，是否會影響打擊的球速，這正是本研究想要探討的。由實驗結果得知，在擊球前後時期，推擊與一般打擊的身體旋轉動作有差異，但是在擊球瞬間，二種打擊技巧並無差別，顯示擊球瞬間，不管使用何種打擊方式，打者會將動作協調至最適宜的觸球姿勢來擊球。然而，對於球速而言，推擊所產生的球速及球棒速度皆比一般打擊來的低，這也可能是因為推擊時的軀幹旋轉動作較慢所造成的，而軀幹旋轉速度減低也可能來自於左腳的預先跨步所干擾。因此，由本研究發現，雖然推擊技巧在動作上，有他的優勢，可以使得打者與一壘壘包距離變得較近，但卻有生物力學其他的限制，這是教練與壘球選手在選擇使用推擊技巧時，所必須要考量的生物力學影響因素。本研究結果未來將投稿於運動生物力學相關期刊。