THE STUDY OF ENERGY LOSS FROM IMPACT ON A CURVED BALL OF GOLF SWINGS

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Practicing and correcting positions and movements without understanding the principles were involved with the ball impact and subsequent flight path. This research was focused on the relationships between energy creation and loss when open and closed clubfaces were used to create a curved flight path of the ball. Based on the results of the experiments, the energy loss from different clubface angles was varied and caused different flight trajectories of the ball.

KEY WORDS: flight path, club face, angle

INTRODUCTION: Golf was a sport full of techniques, the swing postures from the setup phase, to the backswing phase, the downswing phase, to the follow through phase and then the take away phase (Lan & Lin, 2000), all require accuracy and consistency. Normally, during the learning period, repeated practices of the swings is required to attain correct and accurate movements, which however, ignores the consistency of the striking motions and often the curved ball does not reach the expected distance even for a forceful strike. The reasons for this lack of distance are ; inconsistent motion, poor kinetic force summation so that energy is not effectively transmitted to the ball when attempting to achieve a curved flight path. Furthermore, the use of different angles of the clubface to strike the curved ball also influences how the energy is lost and results in different outcomes. During competitions, professional golfers observe terrain of the golf course and weather conditions and strike the ball with different clubface angles to achieve (Williams & Sih, 2002) different spin and thus varying flight paths of the ball. This study therefore seeks to understand the relationship between the ball-striking angle, energy loss at impact compared with that generated and the resultant spin on the ball.

METHODS: The study was conducted by filming golf swing motions of a Handicap 5 amateur (the testee). The testee was holding a Japanese standards Taylor Made R540 shaft golf club, TM-500 PLUS hardness S-FLEX, clubface angle 9.5 degree driver, the club head mass was 0.36 kg, the golf ball was TOP-FLITE XL3000 mass 0.046 kg, radius 0.021 m. Three 90-degree-angle forward swings were struck with the clubface; Opened with the club face aimed to the right with five different angles. This procedure was then repeated to the left. Data from different striking angles were captured using high-speed camera at 5000 fps frame rate and with a shutter speed of 1/3000 second, then analyzed with Silicon Coach Pro motion analysis software to extract images (Figure 1) to analyze the relationship between angular velocity of the curved ball and its energy when the ball was hit by the clubface using different angles.
The images were used to calculate the speeds pre-and post-impact for the club and the ball. The following formula was used to calculate the energy loss of both before and after the strike.

$$E_l = \frac{1}{2}m_h {v_h}^2 - \frac{1}{2}m_b {v_b}^2 - \frac{1}{2}m_h {v_h}'^2 - \frac{1}{2}I_b {\omega_b}^2$$

where

v_h : velocity of the clubhead before the strike

v_h' : velocity of the clubhead after the strike

v_b : velocity of the curved ball after the strike

I_b : moment of inertia of the ball

ω_b : angular velocity of the curved ball

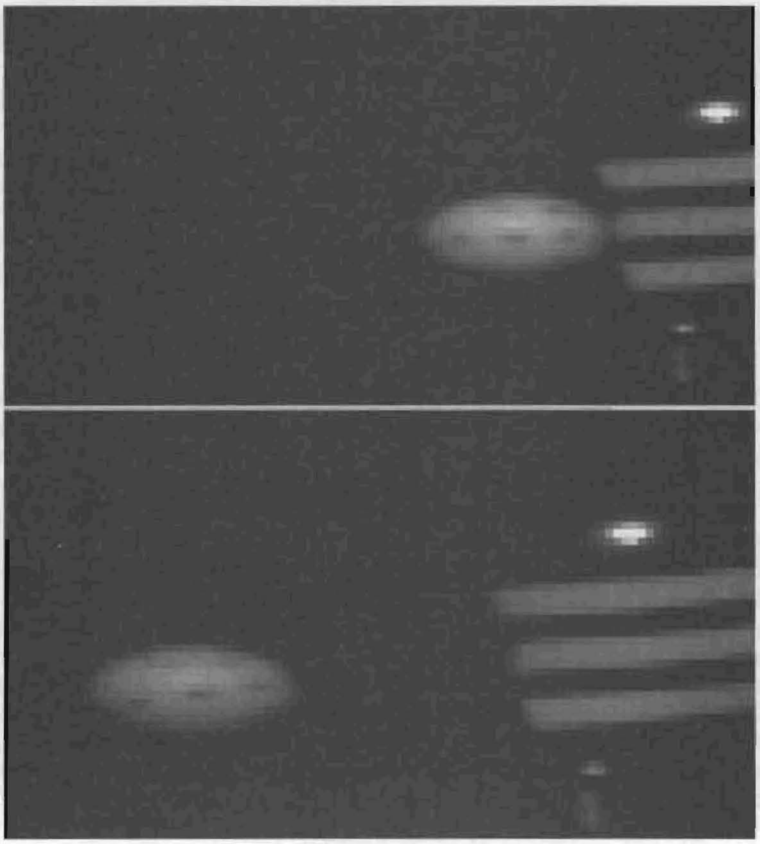

Figure 1 The motion of a golf club striking acurved ball.

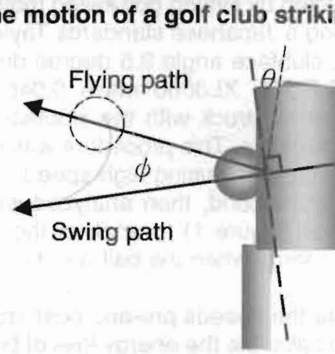

Figure 2 The angles of the swing path and flight path.

RESULTS AND DISCUSSION: This study did not take into account of impact on the curved ball from different shaft mass and only calculated the effects of the clubhead mass on the energy loss owing to the energy transferring after the curved ball was struck in order to avoid computation errors. After the experiment, various calculations were made including: the angle of the club head and the angle of the swing paths for each swing (Figure 2), the speed of various club heads before and after the strike, the angular velocity and the speed of the curved ball, analyzing the relationship between the angle of the clubface and the angular velocity of the strikes (Figure 3). Moreover, to calculate the motion energy of the golf shaft before and after the strikes, the motion energy of the curved ball after the strike and lastly, to calculate the rate of energy loss, to analyze the relationship between the energy loss and the angle of the flight path of ball (Figure 4). In Figure 4, axis x represents degree of the angles; on the right of the zero is positive and on the left is negative.

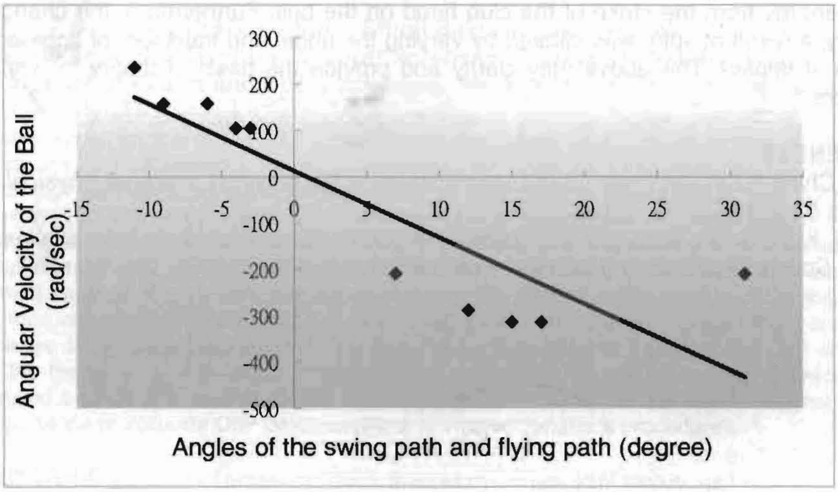

Figure 3 The relationship of the angle of the clubface and the angular velocity.

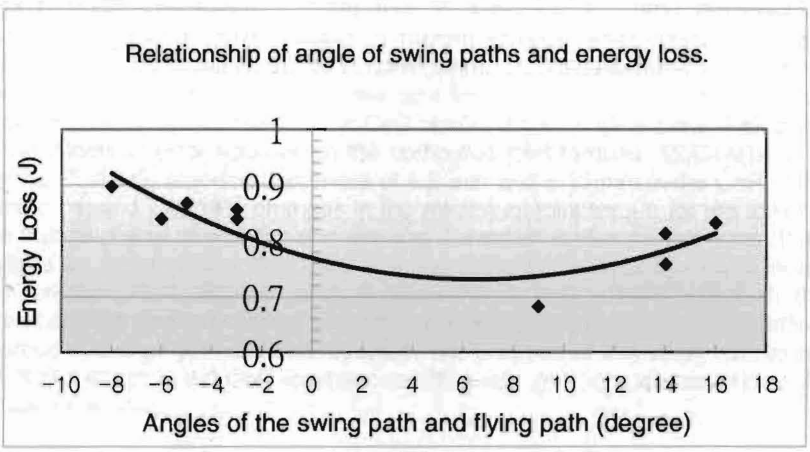

Figure 4 The relationship between the angle of the flying paths and the energy loss.

The above graph demonstrates the conditions between the loss and passing of the energy generated by the club head hitting the curved ball. The speed of the swings did not have major influence on the angular velocity of the curved ball. Based on the Law of Conservation of Energy, the energy should have been shifted completely, therefore, inferences could be made that the loss of the energy was on the sidespin of the curved ball, and the larger the angle of the shaft the larger the loss of the energy. Hence, for precise impact you require lower loss of energy with more energy being transferred from the club to the ball. It was also important to control the angle of the clubface to spin the curved ball to achieve the expected flying path. From the point of view of passing of energy, a good swing should first consider consistency, that was, whether able to pass the whole energy from the club head to the curved ball. That was, if unable to link an energy chain from the whole motion of the swing, a powerful swing would be a waste of energy.

CONCLUSION: The purpose of this study was to verify the theory by experiment to allow golfers to understand the source of energy transfer in hitting a curved ball; to emphasize consistency and rhythm of swinging motions to reduce the energy loss and preserve the highest energy from the strike of the club head on the ball. Furthermore, the change in ball trajectory, a result of spin, was caused by varying the angle and trajectory of approach of the clubface at impact. The above may clarify and provide the basis of theory for various golf instructors.

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