Ball Velocity of a Golf Putt

Pirapong Jitngamplang

Abstract

The relationship between the impact speed of a putter head and the resulting velocity a golf ball was investigated using a high speed camera. Putting strokes were performed by a golfer with a handicap of eight. Tests were done over the full range of typical putting strokes. It was found that the initial velocity of the golf ball was directly proportional to the impact speed.

Introduction

When a golf ball is struck by a putter, the impulse initiates the motion of the golf ball. Not all the momentum of the putter head is transferred to the golf ball. The putter still has momentum after impact. The following equation is a representation of the nature of the putting stroke,

$$m_{ph}\overrightarrow{v_{phi}} - m_{ph}\overrightarrow{v_{phf}} = m_b\overrightarrow{v_b} \qquad \text{(Equation 1)}$$

where m_{ph} is the mass of the putter head, $\overrightarrow{v_{phi}}$ is the velocity of the putter head prior to impact, $\overrightarrow{v_{phf}}$ is the velocity of the putter head after the impact, m_b is the mass of the golf ball, $\overrightarrow{v_b}$ is the velocity of the golf ball.

When a golfer putts, the velocity of the putter head is the most essential factor in determining the velocity of the ball and hence its displacement. The velocity of the golf ball as it leaves the putter head depends on the impact velocity of the putter. Since the correlation of the two velocities is vital to putting success, the relationship between the impact velocity and the velocity of ball as it leaves the putter will be investigated over a normal range of putting strokes.

Figure 1 The experimental set-up. A putter in putting position with the ball and a ruler as reference frame directly over the ball.

Methods

A **Prosilica High speed camera** was set, at 300 frames per second with and a resolution of 350 x 100 pixels, directly perpendicular to the plane of motion of the **golf ball**. The exposure time

was set at 1000 μs. The **putter** striking the golf ball was recorded. The putter used was a Titleist Scotty Cameron Circa 62 Model #2 Putter with a head mass of 0.330kg. The ball used was a Titleist Pro V1 2008 Model Golf Ball with a mass of 0.0456 kg.

Using Logger Pro Video Analysis, the velocity of the putter head just before the impact and the velocity of the ball just after impact was determined. Forty hits were recorded with putter speeds ranging from 0.8 m/s to 2.7 m/s.

Results & Discussion

According to figure 2, the impact velocity and the velocity of ball as it leaves the putter are directly proportional, within uncertainties, for midrange velocities, 0.8 m/s up to 2.4 m/s.

The relationship can be expressed with the equation

$$V_b = (2.03 \pm 0.01)\, V_{ph} \qquad \text{(Equation 2)}$$

The proportionality constant represents the ratio of the velocity of the golf ball after impact to the velocity of the putter head at impact. The golf ball will leave the putter with twice the putter's impact velocity for putts with impact velocities in the range of 0.8 m/s to 2.4 m/s. It can be seen that the ball velocity for the two highest velocity putts is greater than that of the trend, indicating that for high speed impacts the ball velocity increases to greater than twice the head velocity. Given that there are only two data points showing this, further measurements would be needed to confirm this finding.

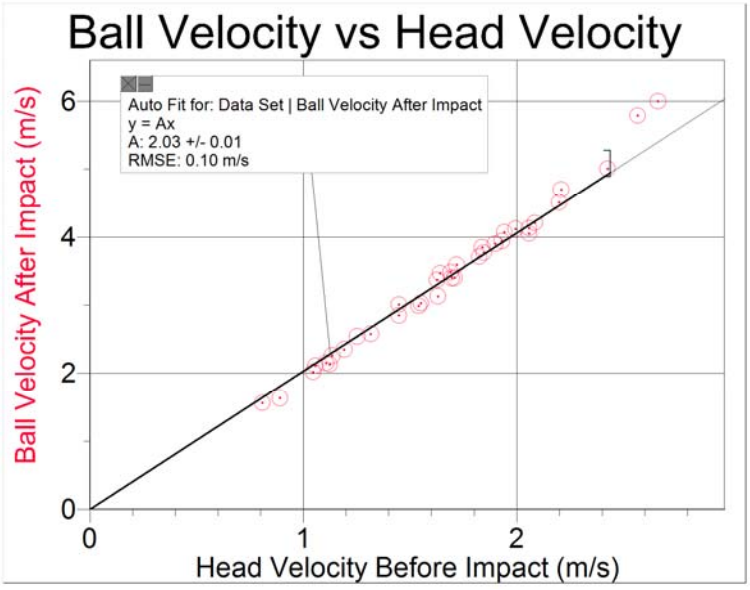

Figure 2 Golf ball velocity after impact versus club head velocity before impact graph with a proportional fitted curve.

If it is assumed that the putter is free swinging at impact, and the collision is elastic, then the law of conservation of momentum and conservation of mechanical energy may be applied. It can be shown that under these conditions the proportionality constant of equation 2 would be 1.75. The ratio shown in figure 2 is 2.03, indicating that during impact an impulse was being applied by the hands, and that the magnitude

of the impulse applied was proportional to the head velocity. For high speed swings, the external impulse applied during impact increased at a rate greater than the head velocity increase, giving a ball velocity more than 2.03 times greater than the head velocity.

Equation 2 shows that golfers can accurately predict that the golf ball will travel at twice the velocity of the putter head at impact. While this is a relationship which can be predicted with confidence, any golfer knows that it takes consistency in the swing, not theoretical knowledge, be a good putter.

A weakness in the method was the changes in the putting stroke for each trial, especially the extremely slow and extremely fast velocities. Since a natural golf stroke was used, there were slight differences in putter head angle, loft, and ball impact location for each hit. To avoid these changes in the putting nature, a putter pendulum could be set up. Instead of using a golfer to putt, a putter could be set up to swing like a pendulum which will simulate free-swing putting strokes. This will also reduce variations in the putting stroke. The disadvantage of this technique is the fact that figure 2 implies that there is an external impulse being applied during impact, indicating that a natural putt is not a free-swinging impact. Any findings using a pendulum swing might not be applicable to a natural swing.

Further research is suggested to determine the consistency and value of the proportionality constant for other putters, golfers, and balls. It is also suggested that further research be conducted using a camera with a higher frame rate and resolution. This would allow research to be conducted using a variety of clubs and balls hit over a range of higher speeds.

Conclusion

The relationship between the impact velocity and the velocity of the ball as it leaves the putter is shown to be directly proportional for all normal putting situations, with the ball leaving with twice the head velocity for the putter and ball used in this investigation. The slight deviation of the final two points above the straight line may indicate that the simple linear relationship breaks down for higher impact velocities.