# THE CORRELATION OF GOLF PUTTING CLUB HEAD VELOCITY AND GRIP FORCE FOR EACH PHASE

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We investigate the correlation of golf putting club head velocity and grip force in different phases during the putting stroke. Five elite college players (handicap: 2~8) executed a putt as accurately as possible to reach a target distance of 12ft. The Novel System and were used to measure the grip force and club head velocity. The lowest club head velocity and grip force both occurred at address up to the top of backswing (phase I). The club head velocity and grip force started increasing during the downswing and reached its peak before impact (phase II), and decreased after impact to finish (phase III). The mean club head velocity and grip force for Phase I, II, III in order are 0.33m/s, 0.92m/s, 0.87m/s; 28.09N, 54.77N, 50.76N. Club head velocity was significantly correlated to grip force in phase II and III (r=0.937; r=0.866). The similar variation pattern of club head speed and grip force may give better control to the putter during the impact and produce more consistent putting stroke.

**KEY WORDS:** motion analysis, grip force, putting

## INTRODUCTION:

Golf performance depends on abilities in driving, wood play, iron play, short game, and putting. Alexander and Kern (2005) indicated that putting ability was the most important skill in determining earnings on the Professional Golf Association (PGA) Tour. At the highest professional level, about 43% of strokes are taken with the putter (Pelz, 2000).

Earl Woods (1997) indicated golf starts with the grip. Everything is transmitted through the hands to the ball. The key element in controlling the club is the hands. They are the body's point of connection to the club, and they control the club, the direction and the distance of the ball. Furthermore, Sander (2003) indicated club head speed, resulting from a combination of translation of the hands, is one of the basic factors contributing to a successful put. Besides, the control of speed and energy transfer of the putter at impact is vital to distance control (Hurrion, 2004).

Tiger Woods (2007) also indicated the importance of grip force in putting. He asserted that light, consistent grip force is one of the keys to allow better club head release. The trouble of pace control in amateurs is due to the improper grip tightness during the stroke, which is just as important as line.

As mentioned above, it is important to have the club head velocity and grip force constant during the impact. However, very few studies have described the correlation of club head velocity and grip force through all the phases. In this study, we investigate the distribution and the correlation of the grip force and the club head velocity of different phases during the putting stroke by using the Pliance-x System and Motion Analysis System.

## METHODS:

Five elite male college golf players (n=5) participated in this study (Table 1). Each participant performed putting 5 times as accurately as possible at a target distance of 12 feet on a large synthetic grass (length 19'10'ft × width 9'5''ft) with a phony hole (diameter 4.25inch). The grip force was measured by using the Pliance-x System Golf sensor- S2035 (1.35cm×1.35cm×64 sensors, Pliance, Novel Inc., St. Paul, MN, USA) with the sensor rolled on the club. The Motion Analysis System with 8 high speed cameras at 150 Hz (Motion Analysis Corporation, Santa Rosa, USA) was used to measure the club head speed and identify each phases with 5 reflective markers on the club. According to Delay (1997) we divided putting into three phases. Phase I was defined by the period from the start position to the top of the backswing, phase II from the top of the backswing to impact, and phase III from the impact to the finish.

Statistical analysis was conducted using Pearson's product-moment correlation (SPSS12.0) at the alpha level .05 between the club head velocity and grip force from measured data. One-way ANOVA with dependent samples was used to test the significant difference at the alpha level .05 between phases I, phases II and phases III for the correlation of the club head velocity and grip force.

**Table1. Phyisical and performance characteristics of the participants.**

| | N | Age(years) | Height(cm) | Mass(Kg) | Experience(years) | Handicap | Deviations*(cm) |
|---|---|---|---|---|---|---|---|
| Men | 5 | 21±1.22 | 172.6±4.04 | 76.6±10.01 | 7.4±2.51 | 4.6±2.41 | 28.9±7.98 |

*The distance between the hole and the ball after the putt

## RESULTS:

One of the typical shots expressed in club head velocity and grip force with time is shown in figure 1. Four participants had similar pattern of the club head velocity and grip force profiles as shown in figure 1. Both velocity and grip force showed similar trend, with a quick leading up in phase II and reaching the peak near impact and decreasing during phase III. However, in phase I, the velocity at start was zero, increased to the middle reaching peak velocity, and decreased from the middle to finish and back to zero; while the grip force remained constant. The mean value of club head velocity and grip force in each phase is show in table 2. The club head velocity and grip force in phase II and III were significantly lower than in phase I.
The correlation coefficient (Rn) was calculated for each trial and each participant (n=25). The correlation between the club head velocity and grip force was shown in table 3. The mean of correlation ($\overline{R}$) was high for phase II and III. The maximum correlation coefficient (Rmax) in 25 trials was highly significant correlated in each phase (Table 3). Referring to minimum correlation coefficient (Rmin), there was highly and negatively significant correlation in phase I, but there was highly positively significant correlation in phase II and III. The percentage of significant correlation coefficient (%R) was 28% in phase I, and 100% in both phases II and III.

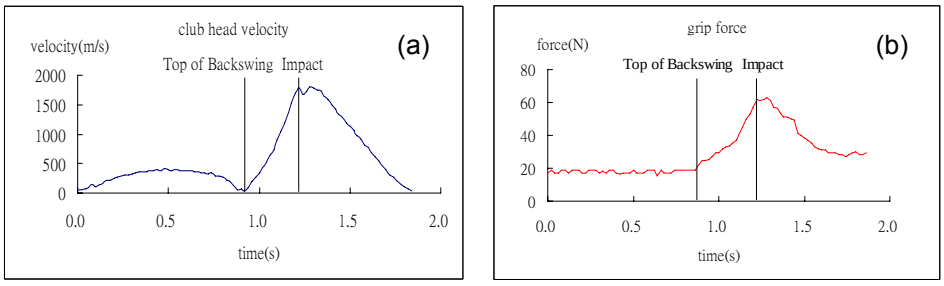


**Figure 1. (a) The typical pattern of the club head velocity during putting stroke. (b) The typical pattern of the club head velocity during putting stroke**

**Table 2. The value of Club head velocity and Grip force in different phase**

| | Phase I | Phase II | Phase III |
|---|---|---|---|
| club head velocity(m/s) | 0.33±0.08 | 0.92±0.12* | 0.87±0.18* |
| grip force(N) | 28.09±15.89 | 54.77±22.94* | 50.76±23.94* |

*:Significant different from Phase I, $p < .05$

## DISCUSSION:

In phase I, the club head velocity increased and decreased smoothly. Putting Dr. (1998) suggests that a slower backswing is required to accelerate the putter through the ball hitting area, which in term results in a crisp ball strike. The grip force in phase I should be kept constant. It may related to the skill of stabilizing as indicated by Leadbetter(1997), of minimizing wrist involvement and ensuring that individual putts are performed with the larger muscles of the shoulders. In phase II, both the club head velocity and grip force had

significantly increased. Sander (2003) pointed out one of the main reasons of increasing club head velocity during the downswing is due to the gravity effect. Therefore, the players need to have firmer grip to hold on the club during the stroke to ensure the pace, which may lead to increasing grip force. The club head velocity and grip force had high correlation(r =0.937) during phase II. During phase III, the club head velocity and grip force were highly correlated (r =0.866), and both peaks were sustained about 0.1 s before dropping. This confirmed the comment from Leadbetter (1997) that the leading hand position, with the wrists locked firmly, is maintained after impact to stabilize the wrist.

**Table 3. Club head velocity and grip force in each phase**

| | Phase I | Phase II | Phase III |
|---|---|---|---|
| $\overline{R}$ (SD) | -0.025(0.557) | 0.937*(0.471) | 0.866*(0.099) |
| R(min) | -0.814* | 0.708* | 0.607* |
| R(max) | 0.703* | 0.998* | 0.984* |
| %R | 28 | 100 | 100 |

*Significant correlation, $p < .05$
R (min): minimum correlation coefficient in 25 trials (n=25)
R (max): maximum correlation coefficient in 25 trials (n=25)
%R: the percentage of significant correlation coefficient in 25 trials (n=25)

## CONCLUSION:

Through this investigation, we found a high correlation between club head velocity and grip force in phase II and III of golf putting. As the club head velocity increased through the downswing, firmer grip force was required to hold the club, giving better control to the putter with more consistent putting stroke. This study has provided some important quantitative insights into the correlation of club head velocity and grip force during the putting stroke.

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