AP FORCE PATTERNS OF THE PROFESSIONAL GOLFERS IN GOLF SWING

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This study focused on the investigation of the changes of the anterior and posterior forces (AP forces) of professional golfers. The subjects were three professional male golfers. Four clubs swing (driver, iron 3, iron 5, and iron 7) for each subject were taken by two high speed video cameras. Two AMTI force platforms were used to measure the AP forces simultaneously. AP force generate CCW moment from the start of backswing to the club vertical, and CW moment until club horizontal in the downswing. Direction of this moment changes again after the club horizontal in the follow through. The sum of AP forces generates forward moment to the golfer's body in the fore phase of downswing. After this time, the sum of AP forces generates backward moment until the club vertical in the follow through.

KEY WORDS: anterior and posterior GRF (AP forces), moment

INTRODUCTION:

The Power in golf swing comes from the large muscles of the trunk. Therefore proper winding and unwinding of the trunk is the one of the essential factors. Usually this motion analyzed using video devices but the forces between the feet and ground that make this twisting is possible could not be analyzed using video. Force platform is a useful device to measure these forces, but there are no sufficient studies about it.

Anterior and posterior forces (AP forces) of the foot acting on the ground generate moments which make the body turn about a vertical axis that lies between the feet (Calsoo, 1967). In the backswing left foot push the ground backward and right foot push the ground forward. This horizontal force couple makes a counter clockwise (CCW) moment (view from the top) and a reaction moment act on the body of the golfer. This reaction makes the body turn to the clockwise direction.

There are a few studies that deal with this topic (Cooper, Bates, Bedi & Scheuchenzuber, 1974; Williams & Cavanagh, 1983; Williams, Jones & Snow, 1988; Barrentine, Fleisig, Johnson & Woolley, 1994). But we can't get detailed data that could be used as criteria for the evaluation of AP force patterns. So the purpose of this study is analyzing the AP force patterns of professionals and makes a criterion for the evaluation of AP force in the golf swing.

METHOD:

Data Collection: The subjects were three right handed male professional golfers who have more than 12 years career, and their mean height and weight were 175.3cm, 86.7 kg respectively. GRF data were collected using two force platform (AMTI) mounted in the laboratory floor. Sampling rate of the force platforms were 1000 Hz. Swing motions were captured using two high speed digital cameras (Photron PCI 500). Picture taken with the frame rate at 125 fr/sec, exposure time was set to 1/1000 sec. For the synchronization of cameras and platforms a synchronize device (Visol, www.visol.co.kr) was used. Four clubs - driver, long iron (I3), middle iron (I5), short iron (I7), were selected for the experiment and same clubs used for all subject to diminish the effect of the club. Subjects requested to swing the shorter club first and every subject made a swing three times. After the data collection for one club was done for all subjects, the next data collection was made.

Data Analysis: Among the three trials for each club, one trial that the subject most satisfied was chosen. From this selected trials, GRF data for the specific events were collected. Total 11 events were set for the analysis based on Sung (2004). From the setup (event 0) to the finish (event 10), every 90 degree rotation of the club viewed from front was set as an event. AP forces at every event collected from the trial of each subject and mean of each event

calculated for the four clubs used. AP force data was normalized by each subject's mass and the unit of forces is %BW.

RESULTS & DISCUSSION:

Figure 1 shows average AP force of each event and there is small deviation for each club. Overall force pattern of each foot is symmetrical, that means that each foot pushes the ground opposite side. This result coincides with the result of previous studies (Williams et al, 1983; Barrentine et al, 1994; Koenig, Tamres & Mann, 1994; Williams et al, 1998).

At the setup (EN 0) there are no AP forces. As the backswing begins (EN 1), left foot pushes the ground behind (-X direction) and right foot pushes the ground forward (+ X direction). This horizontal force couple makes a CCW moment and a reaction moment makes the body turn to the clockwise (CW) direction.

As the club rotate to the vertical (EN 3), the direction of each forces changed, and increased until the club vertical (EN 6) in the downswing. In this phase, counter clockwise moment act on the body because the left foot pushes the ground forward and right foot pushes the ground backward. During the later stage of backswing, this CCW moment makes the rotation of the trunk slower and makes the trunk muscles stretched. Immediately after this time, the rotation of the body to the CCW direction would be more powerful because the eccentric contraction of the trunk muscles in this stage increases the power of the related muscles. Previous study reported that strong correlation exist between the magnitude of AP forces before the impact and the distance of the shot (Williams, 1988).

Also, it is well known action that professionals start downswing before the club reaches the top and this could facilitate the stretch-shortening mechanism of the muscles. Before the impact (EN 6), the direction of left foot push changed to the backward and both foot push the ground backward. These forces make the body rotate backward, so the trunk and arms pull the club inward. And this contributes to the developing more speed of the club because the pulling force (centripetal force) accelerates the body in a circular motion (Miura, 2001).

Figure 2 shows the result of the sum of the forces of each foot at every event. This graph clearly shows that only the forward horizontal force acting in the fore stage of the downswing and only the backward horizontal forces acting in the later stage of the downswing and follow through. Maximum 10 %BW (85.3 N) force act forward direction during the fore stage of downswing and similar force generated at impact (EN 7).

When the club passes the horizontal after the impact (EN 8), the AP force of each foot changed to that of the initial stage of backswing. After this time (EN 8), AP forces make the body rotate CW direction and this make the body rotation slower in the final stage of follow through.

Maximum AP force occurred at the club vertical in the downswing (EN 5) for both foot. Maximum of each club was 0.24 %BW(I5), 0.23 %BW(driver), 0.23 %BW (I3), 0.21 %BW (I7) for the left foot, 0.16 %BW(driver), 0.15 %BW(I5), 0.14 %BW (I3), 0.13 %BW (I7) for the right foot. This result shows a pattern that the longer the club the larger the forces. This result supported by the study of Williams et al (1983) reported that the AP force before impact for the driver, I3, I7 was significantly different. It is considered that the difference comes from the difference of clubs. Longer club has more lie angle and the swing plane became more flat. Therefore the longer club needs more moment than the shorter one.

CONCLUSION:

AP force generate CCW moment from the start of backswing to the club vertical, and CW moment until club horizontal in the downswing. Direction of this moment changes again after the club horizontal in the follow through. The sum of AP forces generates forward moment to the golfer's body in the fore phase of downswing. After this time, the sum of AP forces generates backward moment until the club vertical in the follow through.

AP force pattern shows very small deviation for all subjects and clubs. Therefore the result of this study could be used as a criterion for the evaluation of swing motion in golf. A novice/or intermediate golfer who have significantly different AP force pattern from this study could

enhance their swing by changing the AP force pattern. By comparing the result, we could give an advice to improve that swing.

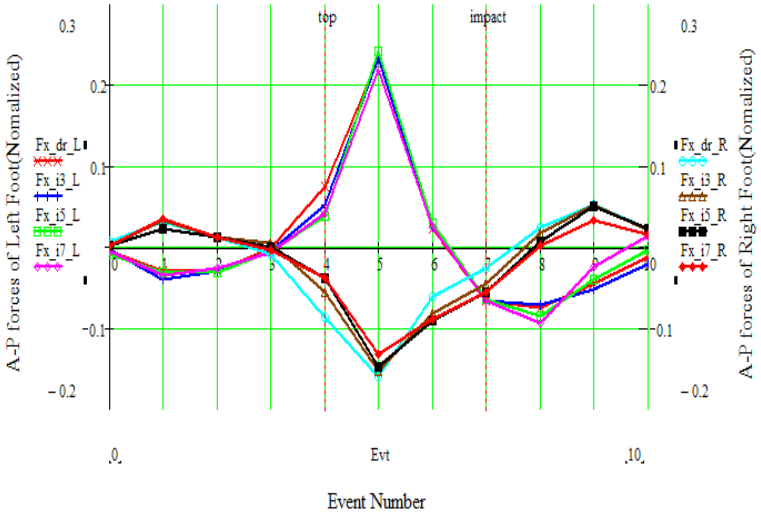

Figure 7: Average AP Force Pattern for Both Feet at Each Event

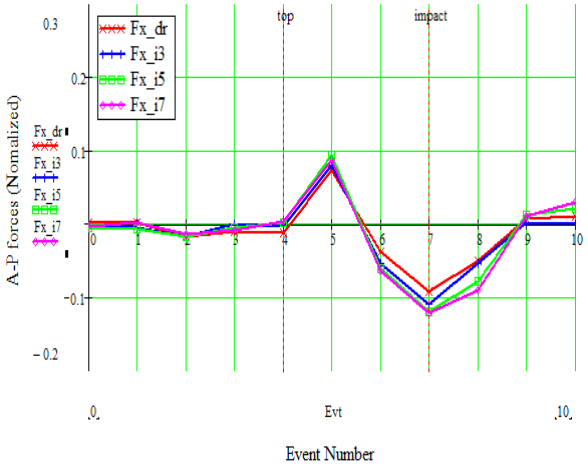

Figure 8: Sum of Mean AP Force at Each Event

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