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Categorization of two different swing styles using weight transfer patterns of golf swing

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국문요약

압력 중심 및 지면반력 이동 패턴에 의한 두 가지의 다른 골프 스윙 스타일 분류

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임영태, 압력 중심 및 지면반력 이동 패턴에 의한 두 가지의 다른 골프 스윙 스타일 분류, 한국운동역학회지, Vol. 14, No. 2, pp. 179-186, 2004. 본 연구의 목적은 숙련된 골프선수들의 골프 스윙 동작 시 상이한 무게중심 변환 형태가 존재하는지 그리고 만약 이 상이한 무게중심 변환 형태가 존재한다면 어떤 형태로 나타나는지를 알아보고자 하였다. 본 실험을 위해 13명의 남자 대학 엘리트 골프 선수들을 대상으로 드라이버를 이용한 스윙을 실시하게 하였다. 수직 지면 반력과 압력중심 이동 패턴을 측정하기 위해 지면반력기 2대와 스윙 동작 시 critical event 설정을 위해 1대의 고감도 비디오 카메라를 사용하였다. 또한 스윙 결과로 나타나는 비거리, 클럽헤드 속도를 측정하기 위해 스윙 분석기를 이용하였다. 피험자 간 상호 비교를 위해 측정된 수직 지면반력 성분은 몸무게를 이용하여 표준화하였고 압력중심은 어드레스시의 압력중심을 원점으로 재 계산하였다. 또한 임팩트 시

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측정된 좌우 수직 지면반력 성분을 이용하여 두 가지의 상이한 스윙 스타일로 구분하였다. 연구결과 8명(62%)의 피험자에게서 좌측 수직력 성분이 상대적으로 높은 전족(FFS) 스타일임이 밝혀졌고 5명(38%)은 그 반대인 리버스(RFS) 스타일임이 밝혀졌다. 이 전족 스타일은 대부분의 골퍼들이 선호하고 또 그렇게 하여야만 한다고 믿고 있는 스윙방식이다. 이와 반대인 리버스 스타일은 코치들이 금기시 하는 스윙의 형태로서 초보자, 즉 비숙련 자에게만 나타나는 전형적인 스윙형태라고 인지되고 있다. 하지만 이 두 가지 스윙 스타일이 초보자가 아닌 숙련된 골프 선수들에게서도 실제 존재한다는 것이 본 실험 결과로 나타났다. 평균 압력중심 이동 패턴은 전후축 방향의 경우 RFS 스타일 그룹이 FFS 스타일 그룹에 비해 압력중심 이동이 크게 나타났고 좌우축의 경우에도 RFS 그룹이 FFS 그룹에 비해 압력중심 이동이 크게 나타났다. 특히 임팩트 시 압력중심의 위치가 FFS 그룹은 전족 근처에 있는 반면 RFS 그룹은 후족(rear foot)에 위치하여 두 스윙 스타일의 차이점을 분명하게 보여주었다. 따라서 비록 이 RFS 스타일이 대부분의 코칭 이론과는 상반되는 무게중심 이동 패턴을 보여주었지만 이 스윙 스타일이 잘못된 것이 아닌 실제 존재하는 하나의 스윙 스타일로 인식하여 스윙 지도 시 이에 알맞은 적절한 교습법을 마련해야 할 것이다.

KEY WORDS : CENTER OF PRESSURE, GROUND OF REACTION FORCE,
WEIGHT TRANSFER PATTERN, GOLF SWING STYLE.

I. Introduction

Since Cochran and Stobbs (1968) published the famous text book of golf biomechanics, 'searching for the perfect swing', which the first comprehensive summary of some extensive testing performed by the Golfing Society of Great Britain, many researchers have studied to find or to better understand proper swing mechanics. A successful swing depends on the performance of a complex sequential action involving the feet and knees, rotation of the hips, trunk and shoulders, and movements of the arms, wrists, and hands. However, above all, the feet initiate the actions of the body in swinging the club as the sole base of support. Studies have shown that the vertical ground reaction force (GRF) reaches peaks in the rear foot immediately prior to the top of the backswing (the initiation of the downswing) and on the target foot just prior to ball impact(Carlsoo, 1967; Cooper, Bates, Bedi, & Scheuchenzuber, 1974). In addition, GRFs indicating the relationship between the forces generated at the heels and at the toes have been

reported(Carlsoo, 1967; Williams & Cavanagh, 1983). Neal(1998) also used GRFs to classify golfers' swing into the translational style or the modern rotational style. Interestingly, a recent study(Ball, Best, Dowlan, & Brown, 2002) argued that two major swing styles may exist; a front foot style which the weight moved towards the front foot during the downswing, and a reverse foot style which the weight moved back to the back foot. In general, the front foot style is the swing style that majority of golfers preferred and believed to be ideal. On the contrary, reverse foot style is the swing style that golf instructors tabooed to use it and only witnessed from the beginners or novice golfers. However, if these two swing styles are found to be all existed not in the beginners but in the low handicapped golf players, it could be very useful fact to know for golf instruction. In this study, because of the importance of the foot-GRFs interaction on the outcome of the swing, it was hypothesized that this action may be indicative of the different swing styles. Therefore, the purpose of current study was to investigate the existence of different center of pressure moving patterns and the different vertical GRFs transfer patterns during the golf swing.

Ⅱ. Methods

13 highly trained male collegiate golfers were recruited as subjects and performed golf swings using a driver. Golfers adopted their preferred stance with each foot placed on separate AMTI force plates (Advanced Mechanical Technologies Inc, Massachusettes, USA). A swing analysis system (PSA 300S, RMTECH, Daegu, Korea) was also used to measure club head speed immediately before ball contact and distance. A digital camcorder (60 Hz) was placed perpendicular to the line of shot and was used to identify seven swing events. These seven critical events were defined as in below.

1. ball address(AD) - instant to start backswing,
2. middle of backswing(MBS) - club shaft parallel to the horizontal plane,
3. end of backswing(EOB) - instant before shaft begins downswing,
4. middle of downswing(MDS) - club shaft parallel to the horizontal plane after EOB,
5. ball impact(IM) - instant of ball/driver contact,
6. middle of follow-through(MFT) - club shaft parallel to the horizontal plane after IM,
7. end of follow-through(EFT) - instant the club stopped its motion momentarily.

An event synchronization unit (Visol Inc, Seoul, Korea) with a light sensor was used to synchronize the video and force plate recordings. At the instant of ball contact, the light sensor activated the unit and a LED which was visible to the camcorder at a same time. Using this method, each critical event was identified with synchronized video image. Figure 1 shows the experimental setup for this study.

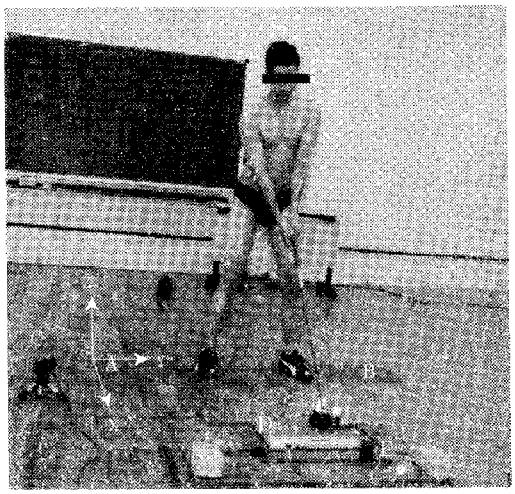

Figure 1. Experimental setup comparisons of mean vertical GRFs for front and reverse foot swing style. A=master force plate, B=slave force plate, C=LED, D=PSA 300S, E=light sensor.

For each swing, vertical GRFs and center of pressure(CP) displacement were measured from two force plates sampled at 500 Hz using KwonGRF 2.0 program (Visol Inc, Seoul, Korea) and were smoothed using a 20 Hz low pass Butterworth digital filter(Matlab). For each trial, vertical GRFs and the time from ball address to end of follow-through were normalized to each subject's weight (%BW) and 100% time for the purpose of comparison, respectively. The center of pressure (CP) data of two separate force plates were combined and considered to be the CP data of one big force plate (Kwon, 1998). The location of origin of global reference frame for combined two force plates was the upper left corner of the master plate (Figure 1). And then, the CP data of each event during a golf swing were recalculated relative to the CP location of address position. The vertical GRFs at the event of IM from two separate force plates were compared to find out if different weight transfer styles exist and categorized into two groups. Independent t-test was performed to find any significant difference($p < .05$) between the two groups. The CP locations were also investigated to trace if any different weight transfer patterns exist.

Ⅲ. Results and discussion

Physical characteristics and some of the kinematic parameters measured in this study were indicated in Table 1.

Table 1. physical characteristics, ball carry distance, head speed, and swing style of subjects

N	Age(years)	Weight(N)	Height(cm)	Distance(yard)	Club head Speed(mph)	Swing style
1	23	687	178	292	126	R
2	21	737	178	266	121	R
3	20	904	176	267	116	F
4	23	773	184	304	125	F
5	21	725	181	283	117	R
6	21	748	175	285	117	F
7	20	696	175	223	102	F
8	20	655	176	306	126	R
9	21	656	176	290	125	F
10	24	709	170	283	116	F
11	21	808	182	283	122	F
12	21	808	175	282	116	R
13	23	815	182	310	127	F

R=reverse foot swing style, F=front foot swing style

Eight out of 13 subjects (62%) showed that the vertical GRFs of lead(the left) foot at IM was higher than that of trail(the right) foot during a golf swing. This is a normal trend of vertical GRFs for golf swing and it is named as front foot swing(FFS) style. In contrast, five out of 13 subjects (38%) showed opposite trend of vertical GRFs which trail(the right) foot at IM was higher than that of lead(the left) foot during a golf swing and named as reverse foot swing (RFS) style. Independent t-test indicated that there were no significant differences between these two groups in terms of ball carry distance and club head speed. Of course, this reverse foot swing style is very different from the reverse pivot that usually noticed from novice golfer who failed to transfer his/her weight to the right during back swing phase.

However, it is interesting fact that some of the highly trained golfers also bear the weight on

the trail foot at IM not on the lead foot at the event. These percentages were very similar to the results of previous study which showed 70% and 30% of their subjects were FFS and RFS styles, respectively (Ball et al., 2002). Figure 2 clearly shows the trend of mean vertical GRFs for these two swing style group.

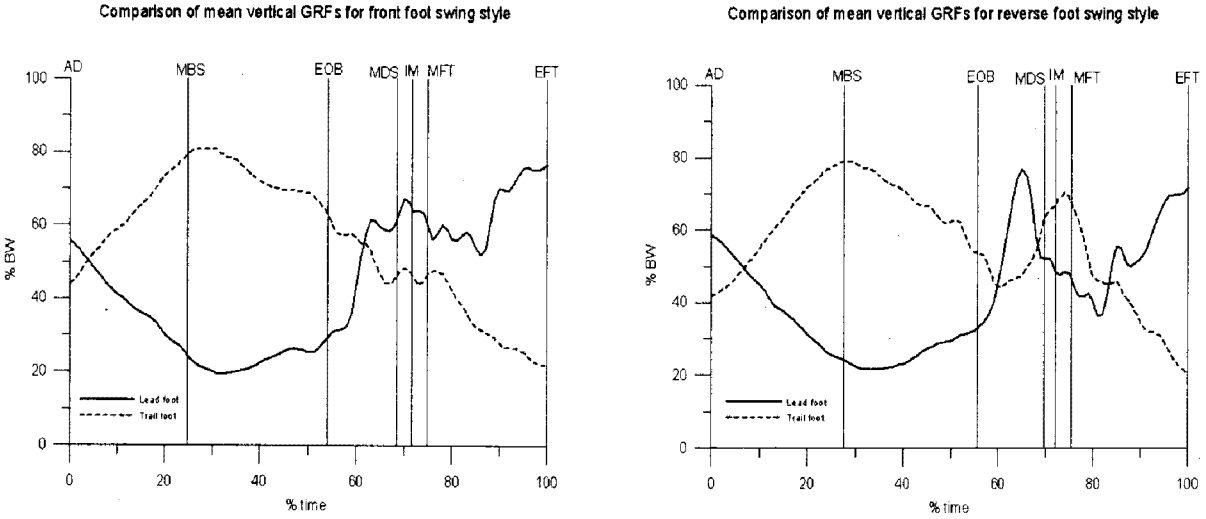

Figure 2. comparisons of mean vertical GRFs for front and reverse foot swing style groups. (vertical line indicates mean critical events of each group)

Mean CP moving patterns relative to the CP of AD position also distinguished two different swing styles (Figure 3). In anterior-posterior direction, FFS style group less moved their CP(2.86 cm) than that of RFS style group(4.45 cm). In medio-lateral direction, FFS style group translated 18.65 cm backward from AD to MBS and moved forward 30.93 cm from MBS to EFT. RFS style group also moved 19.71 cm backward from AD to MBS and moved forward 33.31 cm from MBS to EFT. Interestingly, both groups showed that CP positions of EOB moved to the target direction compared to those of MBS during back swing phase. However, during down swing phase, the CP of both groups moved opposite to the target direction from MDS to MFT. This is unexpected results that both EOB and IM were farther to the target than MBS and MDS, respectively. Particularly, from down swing, the CP movement pattern of FFS style group was found at the first quadrant and that of RFS style group was at the fourth quadrant. This clearly indicated that IM of FFS type was occurred at near the lead foot and that of RFS type was at near the trail foot position. This may imply that FFS style is more effective and consistent swing than RFS type.

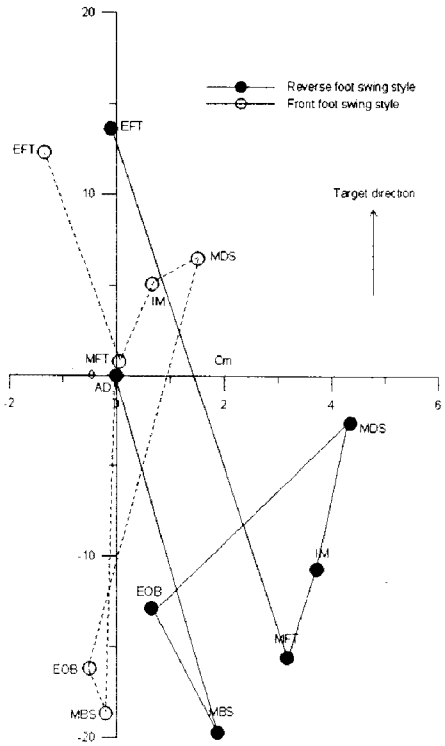

Figure 3. comparisons of mean CP position of critical events for front and reverse foot swing style groups.

In conclusion, this study proved that different weight transfer styles such as FFS and RFS types exist in the golf swing. Both styles showed similar weight transfer patterns in the backswing and during the initial stages of downswing. However, from early downswing stages, the FFS group continued to move weight towards the lead foot while RFS group moved weight towards the trail foot. In anterior-posterior direction, the FFS group positioned weight near the mid-center of foot at IM, while the RFS group moved further towards the toe.

Leading coaches suggest that weight should translate to the trail foot during backswing and then to the lead foot in downswing, and should be positioned on the lead foot at IM(Leadbetter, 1995). However, the RFS group clearly shows a shift towards the trail foot during downswing, especially after MDS, hitting the ball when the weight is located closer to the trail foot than the lead foot. Although this weight transfer pattern exhibited by the RFS group conflicts with the coaching literature on weight transfer, coaches should acknowledge the existence of two different swing styles and must lesson appropriate swing techniques that are relevant to each group. Further studies must be performed to find out the critical parameters which characterize the swing styles with different weight transfer patterns.

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