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Differences in Lower Extremity Electromyographic Responses Based on Foot Position and Swing Phase in Golf Driver Swings

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Abstract

The purpose of this study was to investigate the muscle activity of the lower extremity during driver swing in three-foot positions (Feet Open Stance, Feet Straight Stance, Lead Foot Open Stance). The electromyograms of gastrocnemius, tibialis anterior, and vastus lateralis during swing were measured and analyzed in three sections (take away - back swing, back swing - down swing, and down swing - follow swing). There was no significant difference in muscle activity according to foot position. Muscle activity according to phase was significantly higher in right gastrocnemius and tibialis anterior, and the left and right vastus lateralis in down swing - follow swing. In conclusion, the difference in muscle activity according to foot position is insignificant, and it is considered that the muscle activity to maintain the balance of the body increases toward the end of swing.

Keywords: *Golf, Driver Swing, Foot Position, Swing Phase, Electromyogram*

1. Introduction

The golf industry in korea is developing exponentially. As the accessibility of athletes as well as athletes increases, interest in differences in posture and skills to improve golf performance is increasing. Therefore, experts in the field of sports science are analyzing golf swing more quantitatively and studying the ideal swing mechanism [1], and analysis and discussion are being conducted to provide data that can directly coach in the field through verification of the effectiveness of changing golf technology.

To send the ball to the desired point with a strong shot when swinging the golf driver, it is necessary to perform the correct movement in a balanced state within the stance [2]. For the first time in golf, most practice on a mat on a flat surface at an indoor or outdoor golf driving range, but the final goal is to face the ball on an irregular slope. To cope with this situation, variables such as address and swing plane are adjusted

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appropriately, and the movement of the musculoskeletal system is controlled by adjusting the position of the feet and ankles to balance and swing on the sloping slope [3].

The position of the feet for setup can vary depending on the individual's preference and body shape, but generally, both feet are spread shoulder-width and both feet are placed parallel or 30 degrees outward, but there is no scientific basis for defining correct posture [4]. The position of the wrong foot affects the weight distribution of the setup and the weight movement during the swing [5], and the change in the rotation range of the joints such as the knee and ankle and the magnitude of the pressure applied directly can deteriorate the balance and stability, it can make a swing or be mechanically exposed to damage [4, 6].

In the previous study, when the swing was performed with the type of self-selected, 0 degree of both feet, 30 degree of external rotation of both feet, wide width, and narrow width stance, the decrease in the internal torque of the knee during the external rotation of the left leg occurred in the bilateral-feet external rotation stance and the wide width stance [7]. When swinging with neutral stance type and externally rotated stance type (left foot only) for 7 female professional players, 30 degrees or properly externally rotated stance type can reduce the left knee torque that occurs in follow-through section [8].

From a technical point of view, the change of stance affects the movement of the club, changes the efficiency and pattern of ground reaction, affects factors such as ball pitch, club head speed, and impact, and helps or hinders the distance and accuracy of the game performance. On the other hand, previous studies have not investigated muscle activity according to foot position difference and only deal with the aspect of damage prevention, so it is difficult to use it as a reference for golf fitness training according to posture preference. The purpose of this study was to investigate the muscle activity of the lower limbs during driver swing in three-foot positions.

2. Experiment Materials and Methods

2.1 Subject

The subjects of this study were the active members of KLPGA (Korea Women's Professional Golf Association) who were under 30 years old and had no injury history for the past 6 months and had an average of 74 strokes or less. The final subjects were seven people (age 25.75±1.91 year, weight 64.11±7.42 kg, height 169.24±7.14 cm, lean body mass 46.21±4.13 kg, body fat 27.64±3.07 %) who fully recognized and voluntarily agreed to the purpose and significance of the study and the detailed explanation and precautions of the experimental procedure.

2.2 Experimental Procedure

Before the experiment, the subjects explained and practiced three conditions of stance, Feet Open Stance (FOS), Feet Straight Stance (FSS), and Lead Foot Open Stance (LFOS). Measurement was carried out three times in total, once every two days over 10 days, and the stance condition was determined by random cross-allocation. A total of 9 driver swings were performed three times, and the mean values of gastrocnemius, tibialis anterior, and vastus lateralis were measured during the swing.

2.4 Foot Stance Conditions

Foot stance was set to FOS with both feet extending 30 degrees outward, FSS, with both feet in parallel, and LFOS with only 30 degrees outward and right foot in a straight line. In order to maintain the shape of the same foot during measurement, the target line, the 90 degree line, and the tape were attached to the position of each foot on the batting mat. The three stance types are shown in Figure 1.

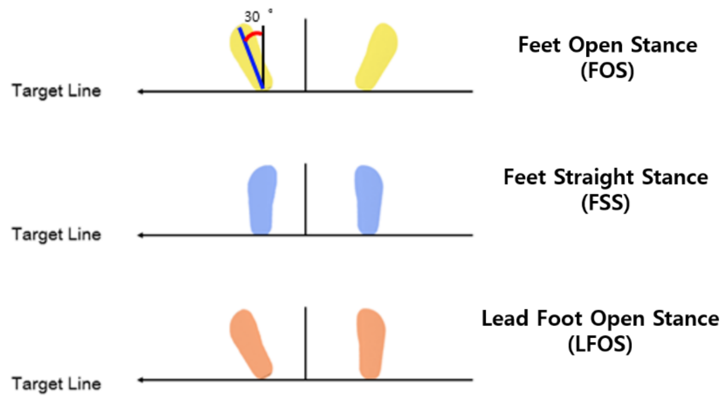

Figure 1. Foot stance conditions

2.5 Swing Phases

The swing was divided into three stages and the EMG response was examined. The three phases are as follows. It is a backswing section that starts from the set-up posture, which is the starting position of the first phase, and goes up to the backswing top. The second phase is a downswing section that starts from the backswing top and refers to the impact after the ball is hit. Finally, the third phase is a follow section that refers to the moment when the finish is caught immediately after the ball is hit. The set-up posture was set just before the club head moved the foot or lower body to move the back swing or weight shift, and the back swing top was set to the posture just before the club reached its peak and the left foot moved to the left. The finish posture was designated as a posture in which the movement of the club and body was completely stopped. The driver swing phases are shown in Figure 2.

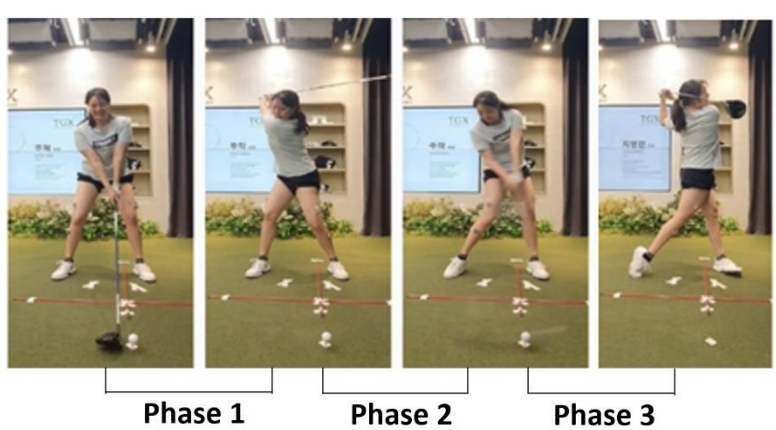

Figure 2. Swing phases

2.6 EMG analysis

Trigno Wireless Biofeedback System was used to measure EMG signals. To obtain more accurate data, the hair at the electrode attachment position was shaved and removed before measurement, and the skin was washed using alcohol swap. EMG of MVIC for each muscle area was measured before swinging. To confirm the concurrency between the EMG signal and the driver swing, the image was taken by arranging the screen so that the swing and the EMG measurement screen can come out together. The measured EMG was converted to RMS, a muscle activity index, and calculated as %MVIC based on the pre-measured MVIC. The attachment position of the surface electrode for the EMG measurement is shown in Table 1.

Table 1. Attachment of surface electrode

Part	Attachment position
Gastrocnemius medial head	A point five fingers wide inside the calf below the popliteal line
Tibialis anterior	A point four fingers down in the tibial tuberosity and one finger outward in the tibial line.
Vastus lateralis	Five fingers out of the femur on the patella

2.7 Statistical Analysis

All the data measured in this study were calculated by using the IBM SPSS Statistics (ver 22.0) statistical program. Muscle activity according to stance and interval was analyzed by repeated measurement two-way ANOVA method, and if there was a significant difference, it was verified by Bonferroni method. The statistical significance level was set at α =.05.

3. Result

3.1 Activity of Gastrocnemius

There was no significant difference in left gastrocnemius activity according to stance condition (p=.198). There was a significant change according to the phase (p=.036), but it was confirmed that it did not reach the significance level in post-test. There was no interaction effect according to group and phase(p=.123). There was no significant difference in right gastrocnemius activity according to stance condition (p=.156). There was a significant change according to the phase (p<.001). In post-hoc test, it was found that the phase 3 were the highest in all stance conditions. The Gastrocnemius activity during swing motion according to stance difference Two-way ANOVA results are shown in Table 2.

Table 2. Activity of Gastrocnemius (%MVIC)

Direction	Foot position	Phase 1	Phase 2	Phase 3		F	P
Left	FOS	18.77±8.56	20.05±11.06	35.70±23.45	Stance (S)	1.858	.198
	FSS	18.06±8.75	20.71±10.35	27.76±12.09	Phase (P)	4.438	.036
	LFOS	18.17±8.11	21.07±9.97	34.71±24.72	S X P	2.024	.123
Right	FOS	10.85±3.44	12.07±5.86	51.82±15.14†	Stance (S)	2.182	.156
	FSS	9.63±3.42	10.78±3.68	43.66±12.60†	Phase (P)	41.560	.000
	LFOS	10.86±4.89	11.01±4.78	46.67±13.30†	S X P	1.201	.336

Mean±SD, †Significant differences before phases

3.2 Activity of Tibialis Anterior

There was no significant difference in left tibialis anterior activity according to stance condition (p=.156). There was a significant change according to the phase (p<.001). In post-hoc test, it was found that the phase 3 were the highest in all stance conditions. There was no interaction effect according to group and phase(p=.336). There was no significant difference in right tibialis anterior activity according to stance condition (p=.156). There was a significant change according to the phase (p<.001). In post-hoc test, it was found that the phase 3 were the highest in all stance conditions. There was no interaction effect according to group and phase(p=.336). The tibialis anterior activity during swing motion according to stance difference Two-way ANOVA results are shown in Table 3.

Table 3. Activity of Tibialis Anterior (%MVIC)

Direction	Foot position	Phase 1	Phase 2	Phase 3		F	P
Left	FOS	6.04±3.35	14.30±16.51	51.22±22.29†	Stance (S)	3.328	.071
	FSS	5.65±3.72	9.90±8.85	48.27±25.23†	Phase (P)	22.262	.000
	LFOS	9.40±12.54	14.56±15.26	41.68±21.42†	S X P	1.247	.318
Right	FOS	11.13±4.97	21.49±16.96	42.55±22.61†	Stance (S)	.710	.511
	FSS	11.08±5.79	19.15±17.40	40.77±16.38†	Phase (P)	23.968	.000
	LFOS	12.07±7.33	22.17±20.45	41.13±22.11†	S X P	.706	.596

Mean±SD, †Significant differences before phases

3.3 Activity of Vastus Lateralis

There was no significant difference in left vastus lateralis activity according to stance condition (p=.156). There was a significant change according to the phase (p<.001). In post-hoc test, it was found that the phase 3 were the highest in all stance conditions. There was no interaction effect according to group and phase (p=.336). The right vastus lateralis activity did not show a significant difference according to the stance condition (p=.156). There was a significant change according to the phase (p<.001). In post-hoc test, it was found that the phase 3 were the highest in all stance conditions. There was no interaction effect according to group and phase (p=.336). The vastus lateralis activity during swing motion according to stance difference Two-way ANOVA results are shown in Table 4.

Table 4. Activity of Vastus Lateralis (%MVIC)

Direction	Foot position	Phase 1	Phase 2	Phase 3		F	P
Left	FOS	6.03±2.40	8.27±2.59	31.19±18.02†	Stance (S)	.804	.470
	FSS	6.19±2.39	8.50±2.76	26.59±19.46	Phase (P)	12.112	.001
	LFOS	6.27±2.26	8.64±3.07	30.27±18.88†	S X P	1.134	.364
Right	FOS	26.97±7.29	41.97±16.90	112.18±126.43	Stance (S)	2.139	.161
	FSS	27.75±8.18	39.37±9.88	82.44±80.93	Phase (P)	3.271	.073
	LFOS	27.02±7.90	36.23±11.53	78.06±68.85	S X P	2.030	.122

Mean±SD, †Significant differences before phases

4. Discussion

The driver swing of the golf game operates to the purpose of to the utmost exact and far sending ball. Since the driver swing plays an important role in moving the ball to the green in a small number of strokes, accurate movement and balance are required to make powerful shots [9]. In order to deliver an accurate impact to the ball through the swing, an efficient weight shift must be made [10]. At this time, the foot kept in contact with the ground affects the smooth movement of the club head and the direction of movement of the ball [11]. In particular, the position of the foot determined in the address posture is determined in the address posture, and since the body segment plays a crucial role in weight shifting for the sequential rotation of the swing, an optimal stance is required for correcting inappropriate impact and for a successful swing [3].

EMG analysis to observe muscle activity during exercise is used as an index of muscle activity because it reflects the amount of motor unit mobilization and force generation [12-14]. In this study, driver swing was divided into back swing, down swing, and follow.

The activity of the gastrocnemius showed a significant difference in the right side by section, and the phase 3 was the highest in all stances. This result is consistent with the previous study that reported that the activity of the right gastrocnemius increased as the driver swing went to the post-impact phase [15]. As the follow section progresses, the length of the muscles becomes shorter as the plantar flexion angle of the right ankle to maintain the axis and trajectory of the swing increases [16, 17]. In addition, the rotation of the lower extremities and trunk during the swing starts due to the contraction of the right calf muscle, and the importance of the right foot movement in increasing the ground reaction force and the club head speed in the golf swing has been emphasized [18].

The activity of tibialis anterior showed a significant difference in both sections and was the highest in the phase 3. In the previous study, it was said that the high activity of both tibialis anterior in the section after the downswing was to minimize the movement of the lower body and induce a sophisticated swing by resisting the rotation of the body [19]. The high activity of the tibialis anterior after impact is thought to be an action to prevent the center from moving backward as the torso is stretched after the impact by exerting the dorsiflexion of the ankle to engage in the stability of the trunk.

The activity of the vastus lateralis muscle was high in the follow section in all sections from the left. The right side was significantly higher in the phase 3 only in FOS and LFOS, and this result is not consistent with the previous study that reported that the activity of both lateral vastus muscles increased after the downswing, but it was the highest in the backswing top-impact section [20]. However, since the femoral muscles are active to maintain the center of the body in the downswing, the activity patterns of the vastus lateralis may be similar to those of the tibialis anterior to induce stable swing [21].

5. Conclusion

The purpose of this study was to compare and analyze the muscle activity of the lower limbs during driver swing according to three-foot positions (FOS, FSS, LFOS) and swing phase at the same stance width. There was no significant difference in muscle activity by stance condition, but the highest muscle activity was found in phase 3 swing section of the right gastrocnemius and tibialis anterior, and the left and right vastus lateralis. In conclusion, the difference in muscle activity according to foot position is insignificant, and it is considered that the muscle activity to maintain the balance of the body increases toward the end of swing.

This result was different from the previous thesis that showed the highest activity in phase 2, but it can be inferred that the results were different due to different research methodology and different conditions. As a limitation of this study, it can be difficult to generalize because many cases are not obtained for KLPGA players, and it is difficult to discuss with other factors affecting swing due to analysis of single variables such as torque and ground reaction force. In the future, it is necessary to apply various variables comprehensively to further study on the relationship between technical accuracy and muscle activity, and how the change in the size of muscle activity affects the efficiency of swing and the physical fitness of the subject.

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