

## THE BIOMECHANICAL STUDY OF BIG TOES IN THE GOLF SWING

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The purpose of this study was to investigate the intensity of force on the big toes of both feet during the golf swing. The subjects were four right-handed golfers; male tournament professional-golfer, male amateur golfer (HDCP 16), female tournament professional-golfer, and female amateur golfer (HDCP 20). There were obvious differences among four golfers in the swing movement, comparing the intensity of force of the right and left big toes. The findings were as follows: Male pro-golfer demonstrated a gradual increase in force on his both big toes. Female pro-golfer confirmed the presence of force on right and left toe with the value 14 Ns and 11 Ns, respectively. On the other hand, the male amateur golfer exhibited high force (11 Ns) on the left big toe. Both the male and the female pro-golfer and the male amateur showed higher force during the back swing (A-T) phase, compared with other phases, e.g. downswing (T-I) and follow-through (I-F). On the other hand, the female amateur golfer showed higher force at I-F phase. It may be considered that during back swing, the more skillful golfer puts force on the big toes of both feet. Results of this study indicated that toe force at A-T phase is an important factor that is required, in order to hit a ball correctly and with power. In addition, results from this study can be utilized for the development of a technique for improving the swing action of golfers.

**KEY WORDS:** golf, swing, big toe, force, acceleration

**INTRODUCTION:** The entire body performs the movement of a golf swing. In the golf swing, the question of how to use both feet correctly is raised. It is of utmost importance to a golfer, as it determines how far and how precisely he will hit the ball. Among golfers there is no consensus of opinion, especially regarding the use of the sole of the foot. It has been determined that the golfer should grasp the ground with the entire sole of the foot, when hitting a ball. In addition, the golfer should apply force on the tip of the toes. To avoid body sway, it is recommended that the golfer exert pressure on the arch of the foot, when on the ground, during a back swing. . Kawashima (1987) made a biomechanical analysis of the sole of the foot during the golf swing and investigated the center of foot pressure that shifts during the swing, using a force plate. The data suggested that the shift of the body weight should be within the range of the centers of both feet. It was also found that the force on the foot sole during the swing was about 1.4~1.6 times of the body weight (in the case of top professional male golfers). However, use of the force plate makes it difficult to detect the delicate force strength from the sole. With regards to the position of the force on the sole, in particular, the area that includes the tip of the toes has not yet been researched. It has been shown that the swing will reflect a lack of stability if the foot force is not adequately stabilized. A more powerful golf swing is the result of the whip motion of the body that is induced by the body rotation and twist. This series of motion will be influenced subtly by the movement of the feet as they interact with the ground. The big toes of both feet, in particular, play a major role in maintaining the balance of the body. The present study aims to provide important information which can be used to improve the performance of the golf swing through biomechanical research of the movement of big toes during the swing.

**Table 1 Anthropometric Data, Career, and Maximal Head Speed of the Subjects**

Item	Sex	Age (year)	Height (cm)	Weight (kg)	Handicaps (0-36)	Career (years)	Maximal head speed(m/s)
Subjects							
Professional golfer (FJ)	Male	36	176	67		16	49.8
Amateur golfer (NT)	Male	38	166	72	16	15	44.5
Professional golfer (NM)	Female	37	162	62		16	40.6
Amateur golfer (OT)	Female	53	153	50	20	15	33.5

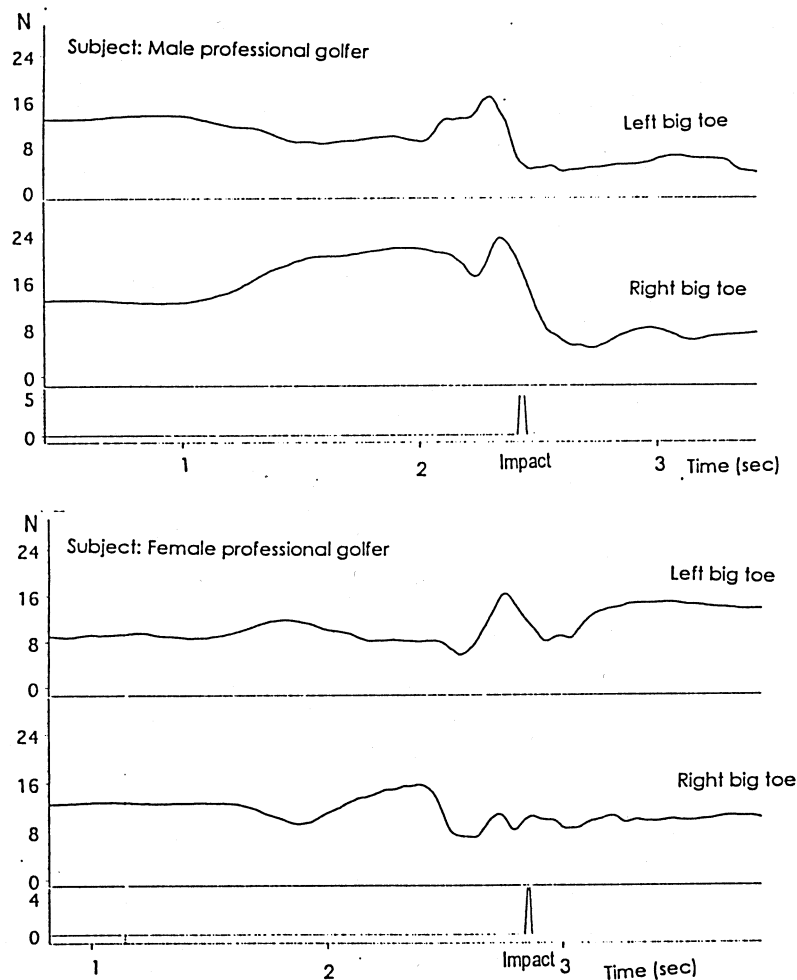
**METHODS:** The subjects for this study were four right-handed golfers. Male tournament professional-golfer, F.J. was awarded a championship from Japanese professional golf driving contest in 1987 and 1992). Female tournament professional-golfer, N.M. was awarded a championship from Japanese ladies professional tournament in 1990. The remaining two subjects were male amateur golfer T.N. (HDCP 16) and female amateur golfer OT (HDCP 20). The anthropometric data, carrier and maximal head speed of the subjects were shown in table 1. They were instructed to hit straight balls with a driver (D). Driver (PRGR; No. 1) used for male subjects with 43.5 inches of shaft length and for female subjects with 42.5 inches of shaft length. Shaft of those drivers was made of carbon. Spike-less shoes were employed for investigation. The direction of the ball was measured with the human eye. The swing was divided into three phases, back-swing (A-T), downswing (T-I) and follow-through (I-F). The forces on sole of toes were measured by small road-cells (diameter 10 mm; S-100 Type: DKH Co. Ltd.), which were placed on to the sole of right and left toes, fixed by adhesive surgical tape, with calibration up to 100 N made individually for each of the cells. Each result was recorded through an amplifier (PH 450: DKH Co. Ltd.). Impulse was integrated from force wave. The swing was photographed by VTR camera at 60 field per second, with a shutter setting of 1/500 s, and analyzed according to Burden, A.M. et al.

On the instep of both feet, an accelerometer was placed, to measure the movement of the instep portion and the maximum acceleration at each part of the swing was investigated. Impact phase was recorded by means of laser sensor (Omron, 1 ms). The dynamic effects of each record were computer analyzed by ADI (Mac Lab Instruments).

**RESULTS AND DISCUSSIONS:** Figure 1 showed changes of force pattern on the left and right big toes during the swing. In male pro-golfer (FJ), the force on both of his big toes gradually increased toward impact as he hit with D. Female pro-golfer (NM) showed same force pattern on left big toe; however, the pattern of the right big toe was obviously different. Male amateur (TN) showed same force pattern of male pro-golfer on right big toe, however, on left big toe the force decreased before impact and then suddenly increased at impact. In the case of the female amateur (OT), the force on left big toe increased to impact and was maintained at higher level thereafter. However, the force pattern on her right big toe was similar to that of the right big toe of male amateur.

Male pro-golfer (FJ) showed high impulse on right big toe, 20.4 Ns, at A-T phase. Female pro-golfer (NM) was found to have an impulse with the value, 14.9 Ns, on right big toe at A-T phase.

On the other hand, male amateur golfer TN had impulses of 11.3 Ns on the right big toe, particularly at A-T phase. Female amateur OT showed an impulse on the right big toe, of 6.5 Ns, at A-T phase. Koenig et al. (1994) studied the shoe-ground interaction during the swing and found that impulse values increased from the downswing to the moment just before the impact. Wallace (1994) et al. compared the spike shoes and the spike-less shoes from the point of pressure migration pattern and reported that the high pressure was recognized on the back part of toe spikes.



**Figure 1 - The force waves on the left and right big toes using the driver.**

This indicated that it is recommended for golfers to firmly plant their feet on the ground, using the toes, when the golfer swings. The movement of feet plays an important role in supporting the body and maintaining the body balance with the workings of toe joints. It appears that a golfer's feet perform delicate movements. During the investigation, high force was recorded from the toes of both feet in the A-T phase, in the case of the male and female pro-golfer FJ, NM and male amateur golfer TN. On the other hand, on case of female amateur golfers, ON, higher force was observed in the T-I and I-F phase, individually. Generally speaking, to avoid power loss, right hand golfer should avoid the tendency to sway their hips to the right during back swing. By exerting force on the sole of the foot, a golfer can save energy to be used to rotate the body, thus eventually making it possible to control

the ball. For both male and female Pro-golfers (FJ, NM), one of the points they are careful about, when starting to swing, is placement of strong force on their toes. In the case of male and female amateurs (TN, OT), however, the above motion was less observed. In the golf swing, the movement of the area from the lower back to the heel will affect every part of the body.

As for the big toe of the left foot, in the case of the male and female pro-golfer (FJ, NM) and male amateur (TN), the force was highest at top of the swing. In case of female amateurs (OT), the force on big toe was highest through impact to I-F. Barrentine et al. (1994) studied golf swings by means of a force plate with golfers of different skills. It was found that the maximal vertical force was recognized at downswing.

The force on the bottom of the big toes of both feet was investigated with four golfers, using the specified club, and the following findings have been observed. Male and female pro-golfers (FJ, NM) and male amateur (TN) put force on the big toes of both feet during back swing, but put less force during downswing and at follow-through. On the other hand, female amateur (OT) put higher force on the big toes through impact to I-F. Different force patterns were recognized between professional golfers of both sexes and male amateur, and female amateur. It may be considered that during back swing, a skillful golfer will put force on the big toes of both feet.

Result of this study indicated that toe force at A-T phase is an important factor required in order to hit a ball correctly and with the maximum power. In addition, the results of this study can be utilized for the development of a technique for improving the swing action of golfers.

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