

**KINETIC ANALYSIS OF EACH HAND DURING GOLF SWING WITH USE OF AN INSTRUMENTED GOLF CLUB**

Sekiya Koike, Hitoshi Shiraki, Norihisa Fujii and Michiyoshi Ae  
 University of Tsukuba, Ibaraki Pref., Japan  
 Institute of Health and Sport Sciences, koike@taiiku.tsukuba.ac.jp

**INTRODUCTION**

The roles of the upper extremities during golf swing are transfer of the energy generated by the lower extremities into a golf club and control the club head to place in a hitting point. Since the golf club is manipulated by both hands in swing motion, the upper extremities and the club make a closed multi-segment loop. Therefore it is impossible to determine the forces and moments acting on the club by each hand with only visual information of motion of the club. The purpose of this study was to investigate three dimensional kinetics of each hand using an instrumented golf club to measure forces and moments exerted on the grip handle of the club.

**METHODS**

Figure 1 shows the structure of the instrumented grip handle. Eleven pairs of strain gages were attached on the outer diameter of an aluminium light weight rod. These strain gages were used to calculate: 1) The torsional moment acting on the grip axis between the hands; 2) The bending moments; and 3) The tensile and compressive axial forces. The output of the sensors was converted into the values of forces and moments by resolving the static equilibrium equations. Two spherical markers with negligible-mass shafts were attached on the club shaft for the purpose of measuring the orientation of the moving club. Two professional golf players volunteered to participate in this study as subjects. They swung three kind of clubs such as driver, number 5 Iron club and sand wedge. The positions of markers of the body segment endpoints and of the clubs were captured with VICON motion analysis system operating at 250Hz. A personal computer was used to store the strain gauge signals that were amplified through dynamic strain amplifiers. The sampling frequency of the force and moment data collection was 500Hz.

**RESULTS AND DISCUSSION**

Figures 2 (a) and (b) show the forces exerted by each hand with respect to subject B during forward swing motion with the number 5 Iron club. These values are expressed in a swing club coordinate system  $\Sigma_{swc}$ , where the unit vectors of  $\Sigma_{swc}$  were defined as follows:  $z_{swc}$  is a normal unit vector of the swing plane,  $y_{swc}$  is a unit vector from club head to grip-end and  $x_{swc}$  is a unit vector perpendicular to these vectors. The horizontal axes of the figures denote normalized time from the beginning of forward swing motion (0%) to the impact (100%). The  $x_{swc}$ -axial force of the head side hand decreased slightly toward 30% time and increased gradually in the period of about 70% time, and then decreased rapidly toward the impact. The  $x_{swc}$ -axial forces of the hands showed inversion patterns approximately with respect to sign. The result indicates that the forces acted as couple force and did not accelerate the rotational motion along the swing plane just before impact. The  $y_{swc}$ -axial force of the head side hand kept constant value by 70% time and increased dramatically and reached the peak at approximately 90% time, and then it kept

the peak value toward the impact. On the other hand, the  $y_{swc}$ -axial force of the grip-end side hand showed a different pattern, increased gradually from 80% time to the impact. The resultant force increased gradually toward the impact due to increase in centrifugal force.

**CONCLUSIONS**

To investigate kinetics of each hand during golf swing motion, an instrumented golf club with strain gauges was used to solve the closed multi-segment loop problem. From the results, the kinetic responses of the two players showed considerably different patterns with use of the clubs. The ability to quantify acting forces and moments of each hand during golf swing has the potential to (1) understand the mechanics of swing motion, (2) provide useful information for prediction of injury due to inappropriate swing.

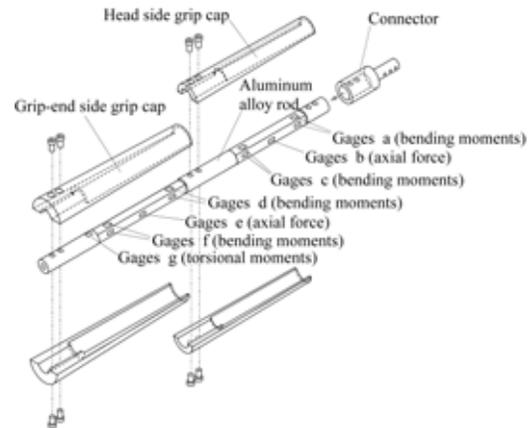


Figure 1: The structure of the instrumented grip handle.

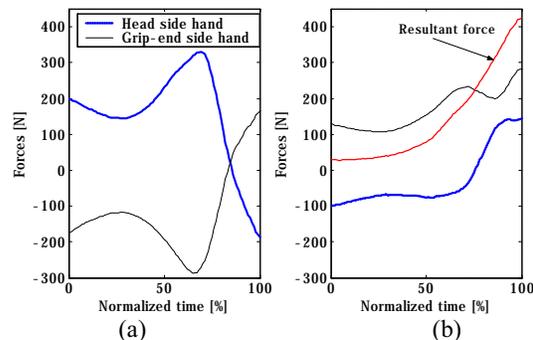


Figure 2: Kinetic responses of each hand during swing motion with the number 5 Iron club. (a): The forces along  $x_{swc}$ -axis. (b): The forces along  $y_{swc}$ -axis.

**REFERENCES**

Koike, S. et al. Kinetics of the upper extremities during baseball batting, *Proceedings of ISB XIX*, Dunedin, New Zealand, Abstract 212, 2003.  
 Koike, S. et al. An instrumented bat for simultaneous measurement of forces and moments exerted by the hands during batting. *The Engineering of Sport* 5, 2, 194-200, 2004.