PERFORMANCE EVALUATION OF DIFFERENT GOLF SHOES USING KINEMATIC AND KINETIC ANALYSIS

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SUMMARY
The main reason of the slow development in golf shoes is the lack of a systematic scientific approach to include the analysis of the human adaptive characteristics when using such equipments. More kinetic analysis should be added to the traditional plantar foot pressure, ground reaction force and 3D motion analysis [1, 2]. Here in this study the kinematic and kinetic characteristics of the golf swing when different shoes were used was analyzed and a visualization method will be proposed in the future in order to assist the development of new golf gears or help how to coach the golf players.

INTRODUCTION
The improvements of golf shoe are not so prominent compared to the sophisticated development of golf clubs and balls [3, 4]. The main reason is the lack of a systematic scientific approach to include the analysis of the human adaptive characteristics when using such equipments. Even when there is a difference between the subjective evaluations of each shoe it is difficult to evaluate quantitatively the performance based only on the insole pressure and/or GRF. The final goal will be focused on how to find a correlation between head velocity and ball trajectory with swing motion, joint torques, foot pressure and GRF. In order to analyze the kinetics of the upper part of the body the closed chain problem need to be solved. In this primary work mainly the lower limb kinematic and kinetic characteristics of the golf swing was analyzed

METHODS
The swing motion of four right-handed single digit handicap golf players were measured using a 3D motion capture Vicon system with 16 cameras at 250Hz. 53 reflective markers were attached to the subject and 3 markers were attached to the driver. Two AMTI Force Platforms were used to measure the ground reaction force and an artificial grass was attached over each platform. The plantar foot pressure was measured using a F-Scan System. The experimental overview, the motion captured model and the model made by Visual 3D and used for kinematic and kinetic analysis are shown in Figure 1. The clockwise (CW) direction from the view of the subject corresponds to the positive rotational torque. The forces and position coordination system are also shown in Figure 1. Due to the variation in the latency of the F-Scan synchronization trigger all the measurements were synchronized by the time of impact. The impact was estimated from the deceleration of the driver measured from the attached markers.

Three different soft spike shoes were used in the experiment. Shoes A have a new spike pattern and a more stiff sole. Shoes B are the lightest and most flexible type and Shoes C have an insole to support the arch of the foot. After the subjects performed some training shots and became comfortable with each shoe, 5 trials were measured.

RESULTS AND DISCUSSION
In this study the golf swing was divided into 7 phases or instants which are: 1. Address, 2. Backswing, 3. Top, 4. Downswing, 5. Impact, 6. Follow-through and 7. Finish. All the phases/instants were identified automatically based on the head velocity and/or head position and they are indicated in Figure 2 by the vertical lines. The 5 trials of 3 shoes, a total of 15 trials are shown in Figure 2 and the average of each shoe is shown by a thick line in Figure 2a, Figure 2b and Figure 2c. Although all the subjects’ subjective evaluation pointed out the Shoes A as the most preferable one, excepted for Subject D, not all of them showed an improvement in the head velocity (Figure 2a), vertical GRF (Figure 2b) or torque (Figure 2c). The difference of the mean head velocity by the Subject D using Shoes A was about 1 m/s. This difference was more accentuated in the vertical GRF of the front foot and even more in the rotational torque of the back foot (Figure 2c). It can be inferred from this analysis that the energy stored during the backswing is than transferred to vertical GRF and eventually to the driver. But during this transfer some energy seems to be dissipated by other joint movements.

Figure 1: Measured swing motion and models used in the kinematic and kinetic analysis.
The very small variation of the hip angle indicates that the subject can maintain the same hip rotation but can change the acceleration in order to achieve a higher torque and consequently a higher head velocity (Figure 2d). Another interesting strategy adopted by the golfer is the hip movement which achieves the maximum rotational velocity just before the impact (Figure 2e). During the impact the hip become stiff and brakes, indicated by the maximum deceleration (Figure 2d), so the torso can rotate over it with more stability. The subjects showed an adjustment of the plantar pressure (Figure 3) in order to maintain the equilibrium and also to avoid slippage. Further analysis has to be done to associate more clearly the role of these adjustments during the swing motion.

CONCLUSIONS

It was found that the differences found in the rotational torque became smaller in GRF and head velocity through the swing motion. Even when the subjects felt the difference in the shoe it was not clear in the kinematics and kinetic data so far. Further analysis of the lower part of the body are being conducted to calculate the ankle and knee joint torques to understand the energy flow stored in the early phases of the golf swing. This analysis can bring new insights about the subjective feeling and kinetic data. Furthermore, in order to calculate the upper part of the body kinetics, a regression algorithm combined with an optimization programming is in development. These results are expected to be present at the congress.

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REFERENCES


Figure 2: Synchronized kinematic and kinetic data of all 15 trials of Subject D (BW=63kg) using 3 different shoes. a) Head velocity. b) Vertical GRF. c) Torque around Z axis. d) Hip rotational angle and acceleration. e) Hip rotational velocity. Thick lines represent the average of one shoe type.

Figure 3: Plantar pressure of three swing instants of Subject D.