KINEMATICS STUDY OF JUNIOR AMATEUR GOLFERS IN SINGAPORE

D. Lim, W. Xie, V. Ong, and K. C. Teh
Singapore Sports Council

Qualitative tools for golf motion analysis like video and graphical overlay have provided competitive golfers in Singapore feedback on their swing. The analysis of this information tends to be subjective due to a lack of reliable quantifiable kinematics information. The authors applied the methods performed by Mc Laughlin and Best [1994], Robinson [1994] and Miura and Nauro [1998] on two professional players and six national age group players. Differences were found in how the two groups of players swing, in particular their setup and translation of their Center of Mass (COM) at Middle of Backswing (MBS) and Ball Impact Frame (BIF). Angle displacement of the shoulder-hip axis was studied and found to be pertinent to the kinetic link analysis. This parameter could serve as an intermediary for quantitative and qualitative analysis.

KEY WORDS: golf, kinematics, professionals, junior amateur.

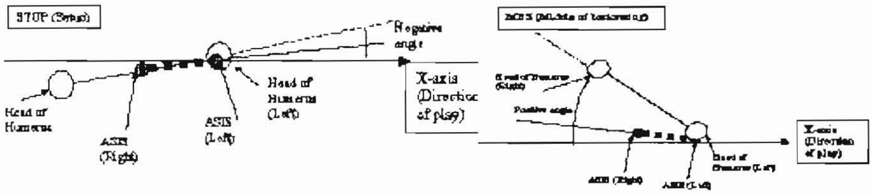
INTRODUCTION: The golfing fraternity in Singapore still relies on qualitative tools like video and graphical overlays to hone their techniques. Although they provide useful feedback, the information provided tends to be subjective. Mc Laughlin and Best [1994], Robinson [1994] and Miura and Nauro [2001], have all been successful in applying the DLT (Direct Linear Transformation) method to study golfers of different abilities. Mc Laughlin and Best [1994] and Robinson [1994] have established the importance of club lag to obtain high Maximal Clubhead Velocity (MCV). It is hypothesized that professional golfers swing the golf club differently from junior amateurs. This study aims to establish a relevant method to test the performance of local competitive golfers.

METHOD: Two playing professionals (39.0 0 years; 167.5 5.7 cm; 62.5 5.6 kg) and six under 18 national players (16.3 1.6 years; 172.7 4.4 cm; 67.4 18.9 kg) participated in this study. All participants were right-handed. Participants were briefed on the procedure and their informed was obtained. The SSC ethics committee gave ethics approval for the study. Participants performed 6 teed shots on an artificial mat, towards a net in an indoor laboratory, with a driver of their choice. Three synchronized 50Hz cameras were used to capture raw video graphic footage. Twenty-one body landmarks [Mc Laughlin and Best, 1994] and 5 landmarks on the golf club were identified for this study. The points on the club were namely the end of grip, middle of shaft, hosel, top of clubface and toe of club. The identified points were subsequently transformed, using Motus [PEAK performance technology]. Seven events were defined for this study, they were the setup (STUP), middle of back swing when clubshaft is parallel to the ground (MBS), top of backswing when the backswing ceases (TBS), middle of downswing defined by Robinson [1994] (MDS1), middle of downswing defined by Mc Laughlin and Best [1994] (MDS2), before ball impact frame (BIF), after ball impact frame (AIF) and finish which is approximately 10 frames after BIF (FH) (See Figure 1).

STUP (Setup)	MBS (Middle of backswing)	TBS (Top of backswing)	MDS1 (Middle of downswing1)	MDS2 (Middle of downswing2)	BIF (Before impact frame)	AIF (After impact frame)	FH (Finish)

Figure 1.Definition of events for golf swing.

For each event, 25 kinematics parameters were defined, similar to those defined by MacLaughlin and Best [1994]. The parameters for all the events were subsequently compared between the two groups of players using independent t-test with significance set at p 0.05. For post processing, all kinematics data were filtered with a quintic spline processor to obtain a a best-fit curve. Statistical results were compiled using SPSS version 11. In addition to the statistical and kinematics analysis, the authors also analyzed the displacement of the angle formed by two lines during the swing, projected on the ground (X-Z plane). The first line joins the left and right head of humerus and the other joins the left and right side of the anterior superior iliac spine (ASIS) (See Figure 2). The authors also chose 6 random trials from one Professional and one Amateur for digitizing. The shoulder, shoulder-hip displacement was calculated. Descriptive statistics for the trials were tabulated and compared for the two players. Limitation for this study is the small sample size. Furthermore, playing experience and equipment used were not factored in this study.



A) Angle displacement at setup. **B) Angle displacement at Middle of Backswing.**

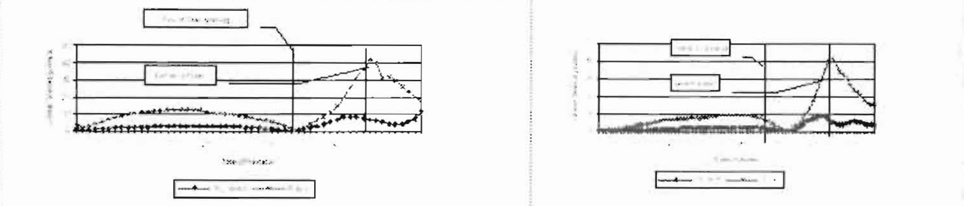
Figure 2: Definition of angle displacement for shoulder and hips against X-axis.

RESULTS: Results from the statistical operation differed from those made by Mc Laughlin and Best [1994] and Robinson [1994] (See table 1 for parameters with significant difference between the 2 groups).

Table 1 Significant difference between professionals and amateurs at golfers at p 0.5.

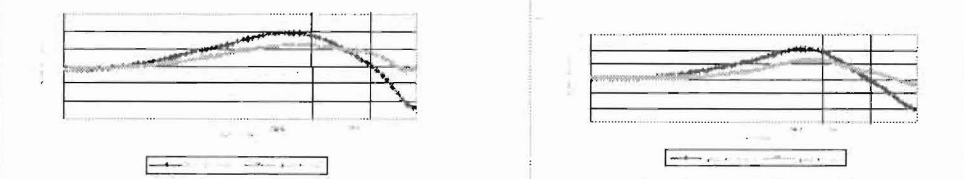
	t	p		t	p		t	p
Right shoulder, elbow and wrist angle at STUP	-4.684	0.0034	Shaft angle to XZ plane at MBS	6.863	0.00047	Change in position of COM in Y direction at BIF	-3.906	0.0079
Angle formed by shoulder and X-axis at STUP	-4.903	0.0064	Change in position of COM in X-direction at MBS	-2.142	0.0490			
Angle formed by knee and X-axis at STUP	-3.833	0.0086	Change in position of COM in Y direction at BIF	-3.83	0.00865			

Comparing the kinematics data (velocity) with Miura and Nauro's (1998) results, Singapore players displayed the wrist deceleration phase prior to impact as described by the author. The differences between the 2 studies would be the Maximum resultant Wrist Velocity (MWV) achieved by the players. Miura and Nauro's [1998] subjects who are professionals and young low-handicappers achieved a MWV of approximately 10 ms-1. Singapore's professionals have a mean of 8.19ms-1 (Figure 3) whereas the junior amateurs' achieved 8.32 ms-1 (Figure 3). A lower MCV (mean=42.33, SD=0.18) was observed for the Singapore professionals, compared to the Japanese players (>45 ms-1). However the Singapore age group players' MCV (mean=41.26 ms-1) were similar to their Japanese counterparts despite the lower MWV. Angle displacement data from Figure 4 shows at address (When frame=1), the hips and shoulders for the players are approximately aligned. The relative angle peaks at TBS and decreases in varying rates. At the frame before impact, the shoulders and hips were not aligned with each other. For both the professionals and amateur, the shape of the graph is an inverted U, with the shoulder-hip displacement peaking at TBS. From Figure 5 and 6, it is apparent that the professional player has a closer grouping for his kinematics data as compared with the Junior Amateur. The descriptive statistics for the 6 trials are in table 2.



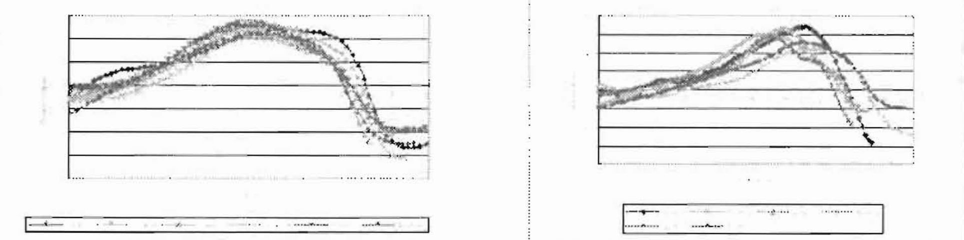
A) Professional B) Junior amateur

Figure 3: Velocity time graph of left wrist and clubhead.



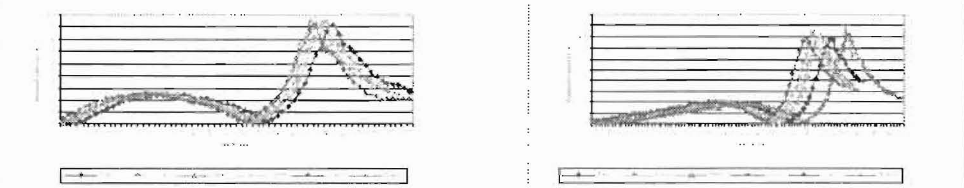
A) Shoulder-Hip displacement for Professional B) Shoulder-Hip displacement for Junior Amateur

Figure 4: Angle displacement for Professional and Junior amateur.



A) Shoulder-Hip displacement for Professional B) Shoulder-Hip displacement for Junior Amateur

Figure 5: Shoulder-Hip Displacement angle for 6 trials.



A) Clubhead velocity for Professional B) Clubhead velocity for Junior Amateur

Figure 6: Clubhead velocity for 6 trials.

Table 2 Mean and standard deviation of kinematics parameters for 6 trials.

	Time to TBS (Frames)	Time to MCV (Frames)	Max Shoulder-Hip rotation (Degree)	MCV (m/s)
Professional	35.857 ±2.193	48.857 ±1.345	49.017 ±4.921	41.465 ±1.116
Junior amateur	57.429 ±5.884	71.714 ±5.122	57.030 ±8.407	40.465 ±1.533

DISCUSSION: Difference in translation of COM for both groups at MBS and BIF reflected the players' anthropometrics difference, especially the muscle mass distribution for the developmental athlete. Club lag was not identified as one of the significant parameters because the junior players are proficient players who were able to generate similar amount of lag as the professionals. Kinematics results yield for this study is similar to that of Miura and Nauro [1998]. For one of the junior players, the angle displacement for his shoulder-hip axis at TBS was more than 74 degrees. His MCV was still lower than the mean professionals and juniors MCV. Furthermore, the junior players have a higher mean shoulder-hip rotation at TBS compared to the professionals. Their mean MCV is still lower than the professionals. It is expected that with a larger shoulder-hip turn, MCV would be higher as pointed out by teaching professional Jim Mc Lean [2001]. He observed that professional players with a long driving distance turn their shoulders considerably at TBS thus coining the term X and Y factor as a measure for the relative shoulder-hip turn. Results from this study seem contrary to his findings. It is possible that with a larger should-hip displacement, extra muscular effort would be required to overcome the inertia forces created, thus not translating the lag created into higher MCV. By applying the open kinetic link concept on the shoulder-hip angular displacement: the hips can be considered the proximal ground link and the shoulders the distal link. The peak of the relative angle coincides with initiation of downswing generated by the proximal link (Hips) and the angle formed between the shoulder and hip axis is considered the lag generated. Visual representation of how the shoulders move in sequence after the hips, the effectiveness of the movement pattern as well as optimal turn could be established for individual players. Kinematics parameters like MCV and MWV should complement this parameter in the analysis as they can be considered a function of shoulder-hip rotation. By incorporating the kinetic link principle to the shoulder-hip displacement graph, the performance of the players in terms of consistency, magnitude and timing of their movement can be visualized. Visual presentation of kinematics data of the wrist, clubhead and shoulder-hip displacement showed that both groups of players have similar playing characteristics. However analysis of intra trials for one professional and one amateur suggests that the professional was more consistent in his performance as the standard deviation for the parameters in the intra trials were lower. As the relevant joints required for this parameter are less and clearly visible for both manual and automatic digitizing, processing time can be reduced to improve sample size. However this parameter needs to be investigated further to ascertain its validity.

CONCLUSION: The authors found that professionals swing the golf club differently from the junior amateur. Differences were identified at STUP, MBS, BIF and AIF. The quantitative platform for golf swing analysis could be based on graphical representation of the shoulder-hip displacement, resultant wrist and clubhead velocity. Thus coaches with experience in qualitative analysis may utilize the additional information to assess player's performance.

REFERENCES:

P.A. Mc Laughlin, R.J. Best (1994). Three-dimensional kinematic analysis of the golf swing, Science and Golf II: Proceedings of the World Scientific Congress of Golf, (eds A.J. Cochran and M.R. Farrallay), E & FN Spon, London, pp. 91-96.

R.L. Robinson (1994). A study of the correlation between swing characteristics and club head velocity Science and Golf II: Proceedings of the World Scientific Congress of Golf, (eds A.J. Cochran and M.R. Farrallay), E & FN Spon, London, pp. 84-90.

K. Miura, T. Nauro (1998). Accelerating and decelerating phases of the wrist motion of the golf swing, The engineering of sport: Design and Development, (ed S.J. Hacke), Blackwell science, Oxford, pp. 455-463.

J. Mc Lean (July, 2001). The Y factor: Your new key to power, Golf Digest, J. Tarde, Advanced Magazine publisher, Trumbull, pp. 78-87.

Acknowledgement

The authors would like to thank the players and officials of Singapore Professional Golfers Association and Singapore Golf Association for participating in this study.