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The Analysis of Knee Joint Movement During Golf Swing in Professional and Amateur Golfers

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***Abstract*—**The understanding of knee movement during swing importance for golf swing improving and preventing injury. Thirty male professional and amateur golfers were assigned to swing time by time for 3 times. Data from a vedio-based motion capture were used to compute knee joint movement variables. The results showed that professional and amateur golfers were significantly in left knee flexion angle at the impact point and mid follow through phase. Nevertheless, left knee external rotation in both groups was also significant. The right knee were no significant different in all variable. However, pattern of knee joint movement are also likely between professional and amateur golfers.

***Keywords*—** Golfer, Knee joint, Movement, Swing

I. Introduction

Golf is the one of the most popular sport in the world. It has been estimated that more than 55 million people around the world participate in this sport and there is the tendency to increase [1]. As numbers of people participating in golf are growing, incidence of golf injuries are increased. Besides low back, the knee is another region that frequently injured. This may be due to modification technique in back swing and follow-through. Incorrect golf swing technique may create more compressive force on the knee joint during both feet were fixed on the ground. Moreover, knee joint structure is not proper for rotation but these movements are essential for golf skill. The chance of knee injury is high risk because this joint has to take body weight and move all the time, this problem is very importance. Research studies have revealed information about golf and knee injuries. According to McCaroll [2] large Q angle and pronation of the feet increase the stress on the patellofemoral joint during the golf swing when valgus forces applied to the knee. A case of osteochondal fracture of the patella has been reported in a golf player. During the follow-though phase, the patella dislocated in the right knee due to internal rotation of tibia.

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Biomechanics of golf swing has been widely investigated in order to improve performance and prevent injury. A recent review by Farrally et al. [1] summarized research finding in golf and identified the application of sound biomechanics to improve golf performance as important. By using qualitative and quantitative analyses tool, to describe the movement pattern of the golfer's swing as well as the resultant of joint torque [3]. In addition Egret [4] showed in his study about kinematic of the golf swing that men flexed their left knee more than women during the backswing. Nevertheless, these two kinematic patterns showed no significant differences in the club head speed.

According to the knee injury in golf swing, it is likely that the understanding of knee movement during swing can prevent and decrease injury. Such knowledge is importance for golf swing improving. In addition, there very few researches about mechanic of knee joint during golf swing, no comparison 3-D kinematics differences of the knee motion between professional and amateur golfers. Therefore, the purpose of this study to investigate and compare three-dimensional kinematics differences of the knee motion between amateur and professional golfers.

II. Methods

A. Subjects

fifteen male professional golfers (mean age 21.87 ± 1.9 yrs; ht. 173.1 ± 5.0 cm; wt. 68.1 ± 10.2 kg) and fifteen amateur golfers (mean age 18.0 ± 1.7 yrs; ht. 172.7 ±5.3 cm; wt. 65.6 ± 9.2 kg; handicap 4.5 ± 2.9) free form hip, knee or ankle injury in the past six months will be recruited for the study. All subjects were right-handed players, and subsequently utilized their left leg as lead leg during the golf swing. They are voluntarily to participate in this experiment. The subjects will be selected by purposive sampling.

B. Instrumentation

Three-dimensional kinematic data will be collected with four high-speed digital video cameras (Basler A504kc from German). Golf swing motion will be captured at the sampling rate of 500 Hz and recorded on a hard drive. Tools are calibrated according to manufacturer recommendations. First, set the area for skill showing, rectangle is set after that, measure the distance of assume axis x, y, z (wide x long x high) that equal 1.595m. x 1.595m. x 1.350m. and use poles or calibration wand for assign value in z axis (Fig. 1). The twelve control points will be used to determine the calibrated volume space via DLT method. The camera calibration wand will be captured for 3 sec and will be digitized later.

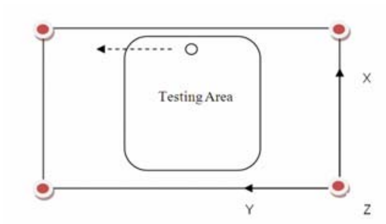

Fig. 1 Position of a calibration wand and global coordinate system

C. Participants preparation

Fifteen retroreflective markers will be attached on right and left lower extremities on the following locations (Fig. 2). Two retroreflective markers will be attached on golf club head and stick. The positions of markers attached on right and left lower extremities are adopted from Helen Hays marker set which has been widely used in gait analysis

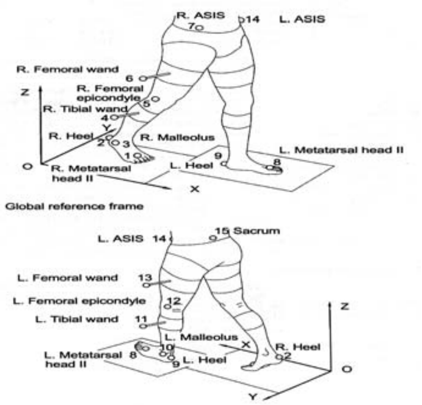

Fig. 2 Retroreflextive markers landmark

Subjects will be suggest to warm-up (static and dynamic stretching) about 5-10 min. in order to prepare body readiness prior to the test. When subjects be ready, starting signal will be sent. In order that subjects must swing time by time for 3 times. Each of swing subjects receive 2-3 min. to rest during data saving.

D. Data Treatment and Analysis

Following data collection, all markers will be digitized using the SIMI Movement Analysis software version 7.5.297. Direct Linear Transformation (DLT-11) method is used to reconstruct three-dimensional raw coordinate data. Raw kinematic data will be filtered with a Butterworth filter with optimal cut-off frequencies determined by residual analysis [5] Segmental coordinate systems of shank and thigh will be established from three non-collinear markers on each segment (fig. 3). Knee joint kinematics then will be determined based on method of Vaughn et al. [6].

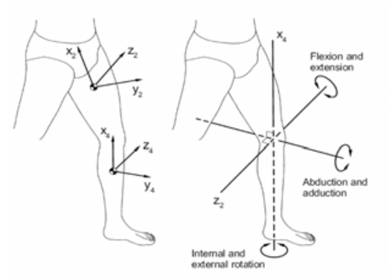

Fig. 3 The reference axes for the left knee for expressing the components of (a) the resultant force at the knee; and (b) the resultant moment at the knee

The statistical package SPSS for Windows (SPSS, Chicago, IL) will be used for all statistical procedure. A Sharpiro-Wilk test will be used to ensure the normal distribution of the data. If the data is normally distributed, independent t-test will be used to determine the differences of three-dimensional knee joint kinematic variables as well as club head velocities between professional and amateur golfers. If the data are not normally distributed, Mann-Whitney U test will be used to determine the differences. Differences will be considered at the p<0.05 level.

III. RESULT

The mean and standard deviation of subject characteristics that evaluated in this study are presented in table I and II. There were no significant difference in all characteristic variables (age, height, weight, handicap) that mean subjects in each group has normal distribution at .05 level.

TABLE I
PROFESSIONAL GROUP

Variable	$\bar{X}$	S.D.	Maximum	Minimum
Age (yr.)	21.8	1.9	25	19
Height (cm.)	173.1	5.0	182	165
Weight (kg.)	68.1	10.2	89.8	53.5

TABLE II
AMATEUR GROUP

Variable	$\bar{X}$	S.D.	Maximum	Minimum
Age (yr.)	18.0	1.7	22	15
Height (cm.)	172.7	5.3	184	165
Weight (kg.)	65.65	9.2	81.9	50.9
Handicap	4.5	2.9	8	0

The resulting kinematic statistics about swing characteristics were presented in table III. No significant in club head velocity at impact point and swing time from top of backswing to impact point between Professional and amateur golfers, but the means of maximal club head velocity before impact for the professional was significant larger than that for the amateur
(p< .05).

TABLE II
SWING CHARACTERISTICS

Variable	Professional (mean ± stdev)	Amateur (mean ± stdev)	p value
Max. velocity (m/s)	42.08±2.44	38.63±3.62	0.00*
Contact ball (m/s)	20.63±2.20	19.38±4.75	0.54
Time to impact (sec.)	0.33±0.05	0.34±0.04	0.83

Nevertheless, the result of knee joint flexion / extension angle for the lead leg in table IV shown that professional and amateur were significantly (p≤ .05) in ball contact and mid follow thought phase. The knee angular velocity of lead and trail leg were no significant between the groups at any of swing phase.

TABLE IV
KNEE FLEEXION/EXTENSION OF LEAD LEG

Left knee Flexion / Extension(°)	Professional (mean ± stdev)	Amateur (mean ± stdev)	p value
TA	12.01±3.03	12.16±3.62	0.93
MB	20.63±2.20	19.38±4.75	0.54
TB	28.92±2.86	25.51±4.93	0.14
MD	9.87±4.58	13.90±5.71	0.18
BC	4.81±1.71	9.53±5.44	0.05*
MF	0.56±7.71	7.72±5.76	0.01*

TABLE V
KNEE ANGULAR VELOCITY OF LEAD LEG

Left knee Angular velocity(deg.s)	Professional (mean ± stdev)	Amateur (mean ± stdev)	p value
TA	2.26±3.10	0.61±0.46	0.53
MB	28.60±4.69	27.40±6.73	0.85
TB	5.37±4.14	9.13±9.29	0.65
MD	233.91±23.95	184.33±30.29	0.13
IM	166.90±33.91	163.43±27.71	0.92
MF	41.50±12.15	55.03±11.01	0.36

TABLE VI
KNEE ANGULAR VELOCITY OF TRAIL LEG

Right knee Angular velocity(deg.s)	Professional (mean ± stdev)	Amateur (mean ± stdev)	p value
TA	1.10±1.02	5.40±2.96	0.19
MB	10.66±5.61	8.81±2.17	0.70
TB	7.54±3.74	8.74±9.19	0.88
MD	137.82±31.43	113.11±10.60	0.40
IM	86.51±19.89	72.03±12.67	0.47
MF	56.49±5.53	42.38±10.29	0.23

Note: TA = Take away, MB = Mid backswing, TB = Top of backswing, MD = Mid downswing, IM = Impact point, MF = Mid follow through.

The table VII shown knee external/internal rotation of lead leg are also significantly different in statistical (P< .05) at mid downswing, impact and follow-thought phase.

TABLE VII
KNEE ENTERNAL/INTERNAL ROTATION OF BOTH LEG IN PROFESSIONAL (PRO) AND AMATEUR (AMA) GROUP

Phase	Left knee Internal/external rotation angle (°)		Right knee Internal/external rotation angle (°)	
	PRO	AMA	PRO	AMA
TA	-5.18±3.57	0.24±2.09	-3.00±4.07	-2.16±1.87
MB	-14.61±4.53	-7.71±2.05	2.32±3.99	6.84±1.02
TB	-26.34±2.94	-20.03±4.94	4.51±3.84	9.44±1.49
MD	0.27±0.89*	7.64±3.77*	-13.48±1.87	-8.04±2.68
IM	2.12±2.09*	10.41±3.11*	-13.36±2.17	-9.90±2.91
MF	4.09±2.25 *	11.49±3.54*	12.28±2.38	-9.01±4.21

IV. DISSCUSSION

In this paper, we presented an analysis and comparison about knee joint movement during a golf swing between professional and amateur golfers. Form the results, we found that the left knee have large flexion in top of backswing and gradually decrease until the mid of follow thought phase. For right dominant swing golfer (almost athletes were right dominant) found stress on left knee while flexion in follow through phase [7], the increasing of rotation affect over stress on knee and lead to injury. So, more flexion/extension angle in amateur golfers bringing them easily to injury than professional. Flexion and extension are importance knee movement as rotation and gliding are less occurred during flexion and extension [8].

Greater left knee angular velocity was evident in professional group at mid downswing and impact point . Since the left foot remains on the ground during the golf swing, the increased velocity may be indicative of the professional golfers moving their hips more towards the target than the amateur golfers [9] that lead to difference significant in maximal club head velocity, for best energy transfer and maximal club head speed in downswing, the theory of proximal to distal sequencing [10] requires several attributes to be evident in a golfer's kinematic sequence; all segments should accelerate then decelerate before impact (except the club which should peak exactly at impact); the peaking force order should be form lower extremity, pelvis, thorax, arm, club and each peak should be larger and later than the previous one.

Nevertheless, from ours study presented external/internal rotation of knee, the study found that left knee are also significantly between professional and amateur golfer that imply to risk of injury from forces and moments generated in knee joint during downswing and follow thought phase. For right dominant swing golfer found stress on left knee while flexion in follow through phase, the increasing of rotation affect over stress on knee [11].

Following results of this investigation, the pattern of knee joint movement in professional and amateur golfers are also likely but difference in some variable that cause form skill level or a habit.

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