INFLUENCE OF THE GOLF CLUB ON THE SWING MOTION

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This study analyzed the influence of the golf club on the swing motion. An experiment was carried out using three 7-irons of different mass and shaft stiffness. Performance was recorded with 10 motion capture cameras, psychological evaluation was evaluated by questionnaire, and the ballistic was measured with a golf ballistic measuring instrument. We analyzed position in the vertical direction of a right wrist marker and considered the flow of the swing motion. We calculated the standard deviation to analyze difference in the swing motion. Comparing the standard deviation, the ballistic measurement results and psychological evaluation, standard deviations could be used as objective evaluation indicators for selecting clubs.

KEYWORDS: human motion, motion capture, golf swing motion, questionnaire survey.

INTRODUCTION: Sport participation and exercise are important activities for maintaining health (Okabe & Yamanaka, 2015). Therefore, many people of a wide age are playing sports in recent years (MEXT, 2016). There are many sports using tools such as rackets and clubs. In such sports, choosing a tool is very important. For example, the proper racket for one's physical, muscle strength and skill, may relax the user, making the ball easier to hit a ball. However, with an improper racket, it gets hard to control the racket, which may lead to injury. Thus, finding the proper tools for individual seems to lead to an increase in competition level. Previous studies have shown that badminton smash motion difference evaluated by the standard deviation (SD) of wrist marker displacement and skill improvement was confirmed in the racket with a small SD. Therefore SD is effective as an evaluation index of racket selection (Kawano, 2017). In this research, we applied this standard deviation to the golf swing motion and investigated whether it was effective as an evaluation index of golf club selection.

METHODS: The subjects were four novice males (age: 22.25±0.95). In the experiment, three 7-irons of different mass and shaft stiffness were used. Table 1 shows the specifications of the clubs. Figure 1 shows the schematic drawing of the experiment setup. Coordinates were set as following. The direction from the subject to the screen was Y, the direction of the front of the body was X, and the vertical direction was Z. Three-dimensional coordinates of 37 reflective markers fixed on the subjects (Pennestri & Valentini, 2010) were obtained with ten motion capture cameras (Optitrack Prime 13, 240 Hz). The ball trajectory was also measured with a golf ballistic measuring instrument (GPRO Skytark). We used a questionnaire to evaluate 20 items in seven stages, and we used the total value as a psychological evaluation. The questionnaire items concerned the comfort of the club. For example, 'easy to swing', 'able to meet' etc. In one experiment, the subjects hit three balls toward the screen. This experiment was carried out three times for one club, and the same was done for each of the other two clubs. Furthermore, two more sets of the above series of experiments were carried out by changing the order of the clubs. To investigate for the influence of the club on swing motion, the SD of swing motion at the time of using each club was examined. It was calculated for the displacement of the marker of the right wrist joint after selecting five swings without data loss. This experiment was conducted with the approval of the ethics committee of Sophia University.

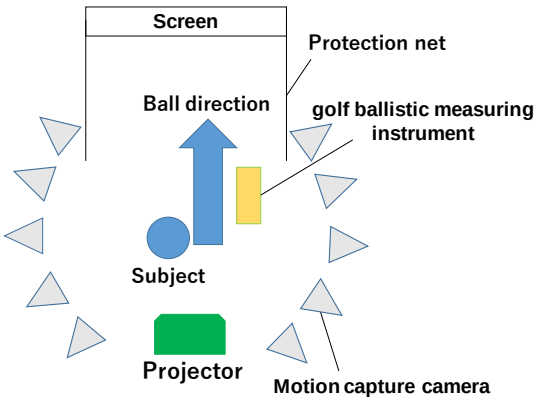

Figure 1: Schematic drawing of experiment setup

Table1: Specification of each club

	A Club	B Club	C club
Length [m]	0.939	0.927	0.933
Mass [kg]	0.401	0.367	0.436
Shaft stiffness [cpm]	314	275	327

RESULTS & DISCUSSION: Figure 2 shows the Z coordinate displacement of the right wrist marker of each club used by the subject 1. It was the average value of five swings. In Figure 2, there are hardly any changes due to differences in clubs. However, there was a difference in the swing using the same club. To investigate the phenomenon in detail, the SD of swing motion at the time of using each club was calculated. Figure 3 shows the time history of the average value of the displacement ± SD, when subject 1 used each club. Figure 3 shows the time interval between 1.8 s to 2.1 s which was the time period around impact time (2.0). Adding the SD from the swing start time to the impact time was considered to affect the ball hitting. Impact start time was the timing to raise from the state holding a club. Table 2 shows the sum of the SD of all subjects. It was considered that an accurate swing was achieved in a club whose sum of the SD was small. The sum of the SD was compared with the ball trajectory. There was hardly a difference between the club speed and the flight distance due to the difference in clubs. Table 3 shows the displacement width of subjects 1 and 2. Subjects 3 and 4 were not able to be measured with ballistic measuring instruments used in the experiment because the ball trajectory was not stable. The displacement width was the distance between the linear axis in the target direction and the falling point of the ball. There was no wind in the ballistic measuring instrument, therefore the shot with the displacement width of 10 yards or more was considered a missed shot. The sum of the standard deviations was the evaluation index of the club selection. Finally, a questionnaire of 20 items, evaluated in 7 stages for each club, was compared with the SD variation. The questionnaire items of the A club was the standard for all four, totalling 80 points. Table 4 shows the sum of 20 questionnaire's evaluation for each club. It is assumed that the sums correspond with club preference. The clubs with the smallest SD sum, and the clubs most liked by the three experimental collaborators, agreed. However, since other rankings did not match, assuming that SD can be treated as an indicator of skills, it is considered difficult to select subjective clubs. Therefore, the sum of SD could be used as an objective evaluation indicator for selecting clubs.

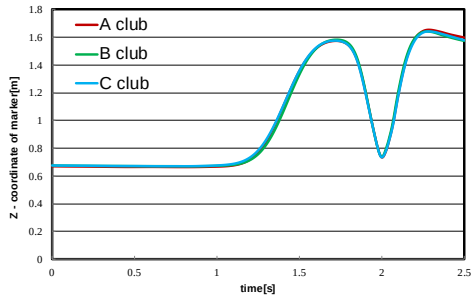

Figure 2: Displacement of the right wrist marker of each club

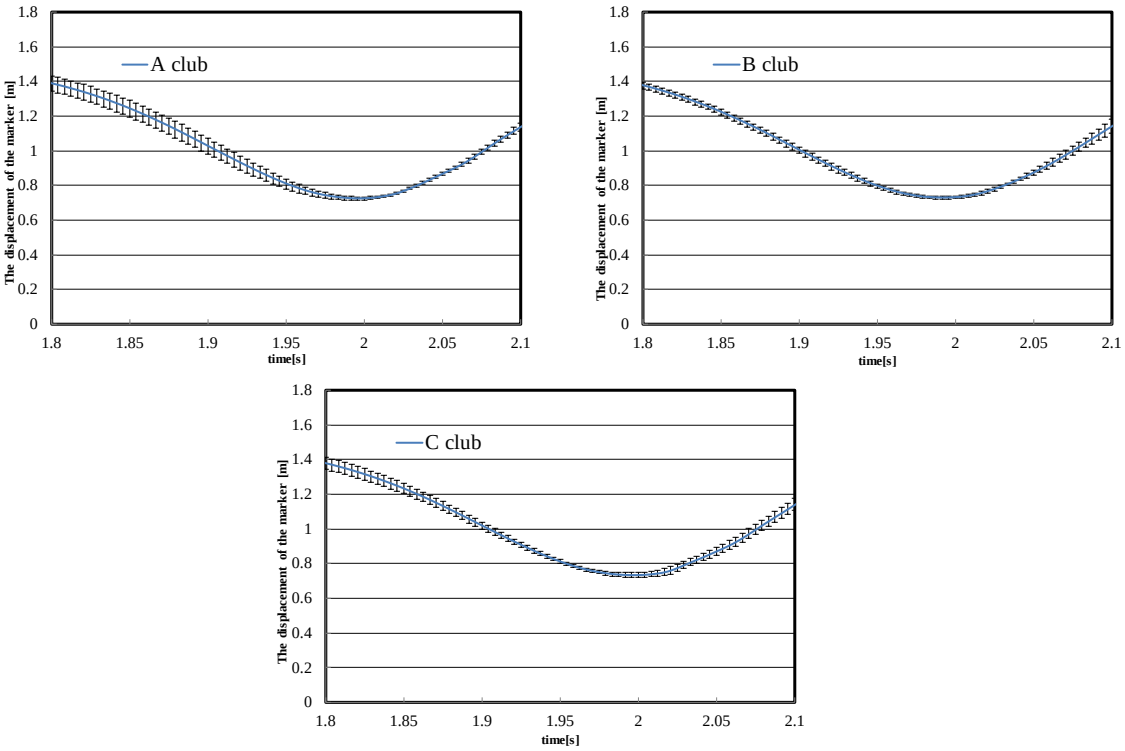

Figure 3: SD of displacement of a marker of the wrist joint

Table 2: The sum of the SD of each club

Subject	A club	B club	C club
Subject1	0.00679	0.00580	0.00942
Subject2	0.01569	0.01082	0.01408
Subject3	0.01253	0.00767	0.01146
Subject4	0.02166	0.02561	0.01445

Table 3: Displacement width [yd]

Subject 1	A club	B club	C club
1	30	2.6	23.1
2	42	31.1	6.7
3	10.7	7.3	12.4
4	1.2	7.2	16.9
5	65.4	33	16.3

Subject 2	A club	B club	C club
1	38.1	7.4	8.3
2	19	21.7	2.6
3	43.4	13.6	35.2
4	7	24	0.1
5	22.7	2.2	30.5

Table 4: Sum of 20 Questionnaire's evaluation

Subject	A club	B club	C club
Subject1	80	109	103
Subject2	80	106	71
Subject3	80	105	75
Subject4	80	58	73

CONCLUSION: The purpose of this study was to analyze the influence of the golf club on the swing motion. By using the sum of the standard deviations, the accuracy of the swing was quantitatively observed. In clubs with small sum of standard deviations, decreases in the number of missed shots was confirmed. The sum of SD might be used as an evaluation indicator for selecting clubs. When comparing the sum of the standard deviations and the preference order, it is difficult to select a suitable club subjectively because their rankings do not match. Therefore, the sum of SD could be used as an objective evaluation indicator for selecting clubs.

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