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Asymmetry of the Isokinetic Trunk Rotation Strength of Korean Male Professional Golf Players

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Objective To determine whether there is side to side difference of the trunk rotation muscle in Korean male professional golf players. Healthy controls who did not play golf were also evaluated and compared with professional golf players.

Method Fifty-one professional golf players and 50 healthy controls participated in this study. Bilateral isokinetic trunk rotation strength that represented the aiming side and non-aiming side trunk rotator function in a golf swing and other parameters were evaluated using the Biodex System III Isokinetic Dynamometer at angular velocities of 30, 60, and 120 degree per second.

Results The professional golf players' peak torque and total work on their aiming sides were significantly higher than on their non-aiming side at all angular velocities. Additionally, the golf players' peak torque on their aiming side was significantly higher than those of the healthy controls only at the 60 degree per second angular velocity, but there was a slight and consistent trend in the others. Finally, the difference between the aiming side and the non-aiming side of the professional golf players and the healthy controls was also significant.

Conclusion The aiming side rotation strength of the male professional golf players was higher than that of non-aiming side. The controls showed no side-to-side differences. This finding is attributed to the repetitive training and practice of professional golf players. A further study is needed to investigate if the strengthening of the trunk rotation muscle, especially on the aiming side, could improve golf performance.

Key Words Golf, Muscle strength, Torso, Rotation

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INTRODUCTION

The golf swing has five phases: the set-up, backswing, the moment when the club is taken away behind the shoulder; downswing, the motion of swinging a club from the top of the swing to the point of impact; impact, the moment when the club strikes the ball; and follow-through that occurs after the ball has been hit. The direction of the direction of the last swing is called the aiming side.[1]

To develop acceleration of the golf club in the downswing phase, the weight of the lower body must be shifted, and pectoralis major, latissimus dorsi, and rotator cuff must be activated1 and the trunk rotation, external oblique of the aiming side, and internal oblique and latissimus dorsi of the non-aiming side are mainly associated. For stabilization of the trunk, the erector spinae, quadratus lumborum, and rectus abdominis are involved.[2-4]

During the golf swing, the lumbar spine and its surrounding structures are exposed to lateral bending forces that are generated when the trunk is bent laterally from an upright position, anterior-posterior shearing forces that exert in the anteroposterior direction, compressive forces that press down discs caudally, and torsion that is developed as a result of twisting of the vertebral segments about the spine.[1] The compressive forces are almost eight times the body weight during the swing, and the torsion is directly associated with the development of low back pain.[5]

The forces generated by the golf swings of both the professionals and the amateurs influence the muscles, ligaments, discs, and joints of the lumbar spine. Professional golfers practice constantly and develop a consistent swing, which places a relatively slight force on the lumbar spine and its surrounding structures, but have problems because of overuse. Amateur golfers do not play as frequently and often have multiple inconsistencies in their swing, which leads to back pain as a result of poor swing mechanics. In addition, recent golf trends tend to focus more on power and driving distance, moving from the classic golf swing that accompanies hip and shoulder rotation, such as that of Bobby Jones or Walter Hagen, to the modern golf swing that emphasizes a large shoulder turn with a restricted hip turn. The modern golf swing places larger forces on the spine and its surrounding structures than the classic golf swing, and causes more significant golf-associated low back pain and injuries.[5]

Professional golfers practice their golf swings repeatedly to improve their golf performance spending 8-10 hours practicing since they were aspiring golfers. This is presumed to result in the asymmetry of the development and functional application of the lateral trunk muscles of the aiming side. As no objective and credible studies have been conducted on Korean professional golfers, to validate the hypothesis that the trunk rotation strength of the aiming side of Korean male professional golf players is superior to healthy controls and another hypothesis that their trunk rotation strength differs from that of healthy controls, the authors assessed the trunk rotation strength of professional golfers who have practiced repeated golf swings for a long period to compare their trunk rotator functions on their aiming and non-aiming sides, and compared these to those of healthy controls.

MATERIALS AND METHODS

Subjects

Fifty-one Korean male professional golf players and 50

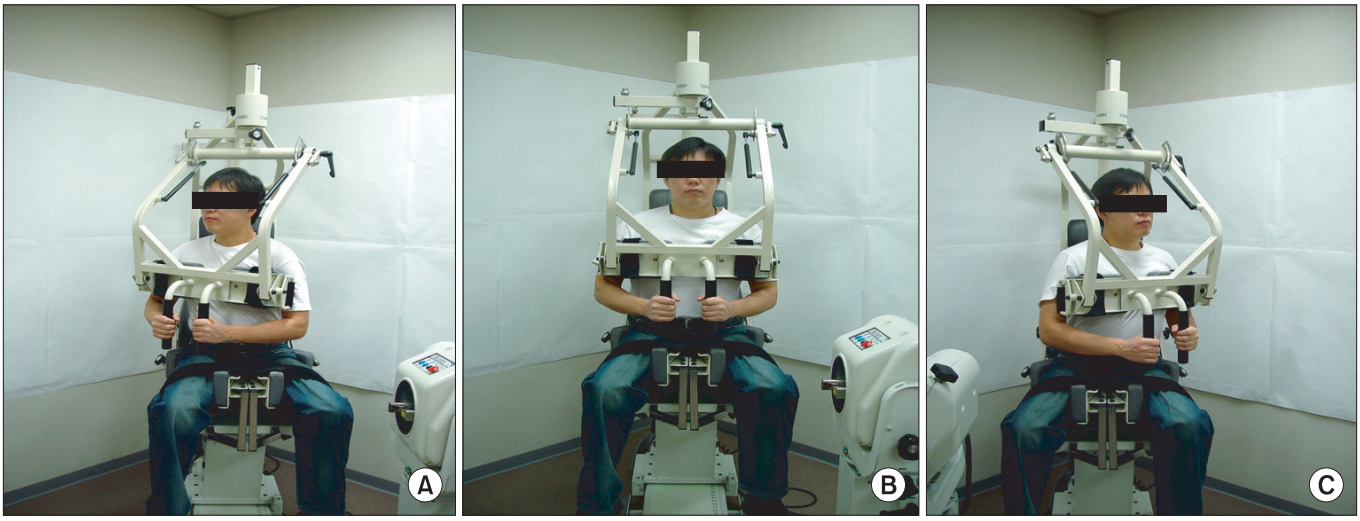

Fig. 1. Biodex System III Torso Rotation Attachment. (A) Non-aiming side rotation (right). (B) Neutral position. (C) Aiming side rotation (left).

healthy individuals who did not play golf participated in this study. None of them had experienced low back pain and injury in the past year. The mean age, golf career, height, and body weight of the professional golfers were 22.31±4.25 years, 9.12±2.92 years, 176.50±5.26 cm, and 74.67±7.89 kg, respectively, and the mean age, height, and body weight of the healthy controls were 21.13±3.07 years, 175.40±5.66 cm, and 69.75±7.91 kg, respectively. Among the 51 professionals, 50 players were right-handed and one player was left-handed. Among the 50 healthy controls, 49 were right-handed and one was left-handed.

The informed consent of the subjects to participate in the following procedure was obtained, and ethical approval was granted by the Chung-Ang University College of Medicine Ethics Board.

Method

The bilateral isokinetic trunk rotation strength of the subjects was evaluated using the Biodex System III Isokinetic Torso Rotation Attachment (Biodex Medical Systems Inc., New York, USA). The axis of rotation of the Torso Rotation Attachment was aligned with the long axis of each subject's spine, and the leg straps and hip pads were tightened to restrict the lower body movement (Fig. 1). When the apparatus had been properly adjusted, the subjects were given an opportunity to perform trunk rotation practice repetitions to become familiar with the desired movement. The subjects were instructed to concentrate on using most of their trunk muscles to perform the isokinetic rotation movements.

In the isokinetic measurement, the angular velocity was linearly related to the peak torque. Angular velocities faster than 120 degree per second may cause problems in measurement.[6] Though the golf swing reaches up to 200 degree per second, the angular velocities in the measurement were set within the traditional range of the peak torque of 60-120 degree per second. The angular velocity at 30 degree per second was also measured due to the characteristics of this study which is required to assess the peak torque. The isokinetic rotations at 30, 60, and 120 degree per second were measured after the ROM limits of the aiming side and the non-aiming side trunk rotation were set at 45 degree. Five trunk rotations in both directions were performed repeatedly, and the peak torque and the total work were measured, with a five-minute rest period between the procedures.

Data analysis

The data were analyzed using PASW 18.0 for Windows PASW (IBM Inc, New York, USA).

All the professional golfers swung to the left as their aiming side whether they were left-handed or right-handed, but the aiming side of the healthy controls could not be determined because they did not play golf. Therefore, in the data analysis, left rotation was categorized as the aiming side, and right rotation was referred to as the non-aiming side. The paired-samples *t* test was used to compare the aiming side and non-aiming side rotations at each angular velocity, and the independent-samples *t* test was used to compare the differences between the professional golfers and the healthy controls with respect to both their aiming side and non-aiming side rotation. Null hypotheses of no difference were rejected if p-values were less than 0.05.

Table 1. Results of the Isokinetic Trunk Rotation Measurement at the 30 Degree per Second Angular Velocity

	Group	Aiming side (left)	Non-aiming side (right)	p-value (paired-sample *t* test)
PT (Nm)	Golfers	140.58±30.92	131.83±27.87	<0.0001*
	Controls	132.60±28.73	138.04±28.63	0.055
p-value (Independent-sample *t* test)		0.243	0.331	
TW (J)	Golfers	747.11±185.49	702.48±187.59	<0.0001*
	Controls	771.16±178.92	760.66±212.79	0.056
p-value (Independent-sample *t* test)		0.562	0.196	

The data are provided as mean±standard deviation values, unless otherwise noted
PT: Peak torque, TW: Total work
*p<0.05

RESULTS

30 degree per second angular velocity

The peak torque of the professional golfers was 140.58±30.92 Nm in the aiming side rotation and 131.83±27.87 Nm in the non-aiming side rotation, significantly (8.75±9.76 Nm) less than in the aiming side rotation. The total work was 747.11±185.49 J in the aiming side rotation and significantly (44.63±69.74 J) less at 702.48±187.59 J in the non-aiming side rotation. No significant differences in the peak torque and the total work were found in the group of healthy controls. No significant differences in the peak torque and the total work between the aiming side and non-aiming side rotations were found among the professional golfers and the healthy controls (Table 1).

60 degree per second angular velocity

The peak torque of the professional golfers was 127.36±26.37 Nm in the aiming side rotation and significantly (9.69±9.60 Nm) less at 117.67±25.20 Nm in the non-aiming side rotation. The total work was 659.64±144.01 J in the aiming side rotation and significantly (31.54±34.84 J) less at 628.10±144.52 J in the non-aiming side rotation. The peak torque of the healthy controls was 117.21±21.66 Nm in the non-aiming side rotation and significantly (4.79±11.40 Nm) less at 112.42±24.76 Nm in the aiming side rotation. In a comparison between the professional golfers and the healthy controls, only the peak torque with respect to the aiming side rotation was significantly different. The peak torque of the professional golfers was 127.36±26.37 Nm, and of the healthy controls, significantly (14.94±25.76 Nm) less at 112.42±24.76 Nm (Table 2).

120 degree per second angular velocity

The peak torque of the professional golfers was 117.03±24.99 Nm in the aiming side rotation and significantly (5.99±6.99 Nm) less at 111.04±23.85 Nm in the non-aiming side rotation. The total work was

Table 2. Results of the Isokinetic Trunk Rotation Measurement at the 60 Degree per Second Angular Velocity

	Group	Aiming side (left)	Non-aiming side (right)	p-value (paired-sample *t* test)
PT (Nm)	Golfers	127.36±26.37	117.67±25.20	<0.0001*
	Controls	112.42±24.76	117.21±21.66	0.024*
p-value (Independent-sample *t* test)		0.012*	0.933	
TW (J)	Golfers	659.64±144.01	628.10±144.52	<0.0001*
	Controls	654.36±166.21	646.97±156.11	0.424
p-value (Independent-sample *t* test)		0.879	0.576	

The data are provided as mean±standard deviation values, unless otherwise noted
PT: Peak torque, TW: Total work
*p<0.05

Table 3. Results of the Isokinetic Trunk Rotation Measurement at the 120 Degree per Second Angular Velocity

	Group	Aiming side (left)	Non-aiming side (right)	p-value (paired-sample *t* test)
PT (Nm)	Golfers	117.03±24.99	111.04±23.85	<0.0001*
	Controls	110.39±24.70	110.61±22.84	<0.873
p-value (Independent-sample *t* test)		0.240	0.934	
TW (J)	Golfers	599.27±148.13	545.36±136.94	<0.0001*
	Controls	578.42±163.76	564.89±157.55	0.099
p-value (Independent-sample *t* test)		0.551	0.553	

The data are provided as mean±standard deviation values, unless otherwise noted
PT: Peak torque, TW: Total work
*p<0.05

599.27±148.13 J in the aiming side rotation and significantly (53.91±36.51 J) less at 545.36±136.94 J in the non-aiming side rotation. No significant differences in the peak torque and the total work were found in the group of healthy controls. No significant differences in the peak torque and the total work between the aiming side and non-aiming side rotations were found among the professional golfers and the healthy controls (Table 3).

Comparison of the differences between the professional golfers and the healthy controls for both the aiming side and non-aiming side rotations

The difference in the peak torques for the aiming side and non-aiming side rotations of the professional golfers at the angular velocity of 30 degree per second was 8.75±9.76 Nm, which significantly differs from the -5.44±15.43 Nm of the healthy controls, yet no significant difference was found in the total work values. The differences in the peak torque and the total work for the aiming side and non-aiming side rotations of the professional golfers at the angular velocity of 60 degree per second were 9.69±9.60 Nm and 31.54±34.84 J, respectively, which significantly differ from the -4.79±11.40 Nm and 7.38±51.60 J of the healthy controls. The differences in the peak torque and the total work for the aiming side and non-aiming side rotations of the professional golfers at the angular velocity of 120 degree per second were 5.99±6.99 Nm and 53.91±36.51 J, respectively, which significantly differ from the -0.22±7.65 Nm and 13.54±45.08 J of the healthy controls (Table 4).

DISCUSSION

To improve athletic performance, it is important for athletes to know the muscles involved in each movement and to practice so as to enhance their muscular functions. To make this possible, motion analysis, EMG analysis that uses surface electrodes, and an isokinetic muscular strength function test are the primary tools. This study assessed the isokinetic trunk rotation strength of Korean male professional golf players who had practiced repeated golf swings for a long period. Comparison of the difference between their aiming side and non-aiming side based on their isokinetic trunk rotation strengths revealed that the aiming side trunk rotator function of the golfers was superior to that of the non-aiming side. The same comparison in the health controls did not differ.

In a study[7] in 2006 of 32 elite male golfers and 40 healthy non-golfing control subjects to investigate the same hypothesis as that in this study, no significant difference in the peak torque of the subjects in their dominant and non-dominant rotations at 90 degree per second was found, unlike in this study. Although the findings of the study in 2006 were not statistically significant, the peak torque toward the aiming side tended to be consistently higher than that toward the non-aiming side. Though tennis differs from golf, repeated trunk rotations are also performed in tennis. In a study[8] of the isokinetic trunk rotation strengths of 109 elite tennis players at 60 degree per second and 120 degree per second angular velocities, female tennis players demonstrated slightly greater backhand rotation peak torques than forehand rotation peak

Table 4. Side-to-Side Differences of the Subjects in the Aiming Side Rotation and Non-aiming Side Rotation

	Side-to-side differences			p-value
	Parameters	Golfers	Controls	
30 degree per second	PT (Nm)	8.75±9.76	-5.44±15.43	<0.0001*
	TW (Joules)	44.63±69.74	10.50±151.28	0.238
60 degree per second	PT (Nm)	9.69±9.60	-4.79±11.40	<0.0001*
	TW (Joules)	31.54±34.84	7.38±51.60	0.024*
120 degree per second	PT (Nm)	5.99±6.99	-0.22±7.65	0.0003*
	TW (Joules)	53.91±36.51	13.54±45.08	<0.0001*

The data are provided as mean±standard deviation values, unless otherwise noted
The values are the differences between the aiming side rotation to the non-aiming side rotation. The positive values mean the parameters of the aiming side are higher than those of the non-aiming side and the negative values mean the parameters of the non-aiming side is higher than those of the aiming side
PT: Peak torque, TW: Total work
*p<0.05

torques, whereas no significant difference was found in the male subjects. Moreover, the statistically significant higher peak torques of the female subjects were not clinically meaningful when compared with the peak torques of the male subjects.

Most professional golf players practice golf swings along with separate exercises for muscular strength and stability, but it is common for them to keep their symmetric balance in such exercises. Moreover, as suggested in a previous study of 118 Korean professional golfers, the mean number of practices per week was 5.4 and the mean number of rounds per week was 3.8, and they reach 1,000 swings per day.[9] Therefore, unlike tennis players who use both forehand and backhand strokes, the major factor that causes side-to-side differences in golf is most likely repetition of one-way swings.

Though the peak torque of the non-aiming side rotation at the angular velocity of 60 degree per second was higher than that of the aiming side rotation in the healthy controls, because the other parameters were insignificant, it is reasonable to judge that there is no difference in the trunk rotator functions in the aiming and non-aiming side rotations in the healthy controls.

The comparisons between professional golfers and healthy controls showed a significant difference in the peak torque of the aiming side rotation only at 60 degree per second. No statistically significant difference was found between the angular velocities of 30 and 120 degree per second, but the professional golfers tended to show greater peak torques than the controls. No statistically significant difference was found in the non-aiming side rotations at all the angular velocities, and the tendency indicated in the aiming side rotation was not seen. Accordingly, the left rotation of professional golfers, or their trunk rotator function on their aiming side, is presumably strengthened through repeated practice, which supports the second hypothesis and validates the differences in the trunk rotator functions of professional golfers and healthy controls.

The total work is used as a parameter of muscular endurance. A previous study[6] found that the total work significantly decreased in golfers with low back pain. Yet due to limitations in the environment at the time of the measurement, not enough rotations were performed, and the total aiming side rotation work of the professional golfers was significantly higher than their total non-aiming side rotation work, requiring cautious interpretation of the results.

Professional golfers are conventionally expected to show greater muscular strength and endurance than healthy control subjects, yet there was a parameter in which the healthy control subjects showed a higher peak torque or total work than the professional golf players, though with difference was not statistically significant. Possible reasons for this are as follows. First, the healthy controls consisted of college students in their early 20s who were engaged in various sports activities. Second, because golf is characterized by intermittently performed rotary motions and instant impulses rather than steady movements for a long period, golfers might have been trained to employ instant maximal muscle strength rather than endurance. Even in a previous study of elite golf players, the measurement of the elite golfers was not always higher than that of the healthy controls.

In the assessment of the trunk rotator function, a five-minute rest period was set between the procedures. This was regarded in a previous study of professional golfers as enough time for the replenishment of the ATP and phosphocreatine stores in the muscle after short-term maximal exercise; but as suggested in the results of this study, repeated tests tended to lead to a decrease in the peak torque and the total work. Therefore, it is suggested that the interval between measurements must be further examined.

CONCLUSION

Based on the results of this study that measured the trunk rotation strength of Korean male professional golf players and compared it with that of healthy controls, both the muscular strength (peak torque) and endurance (total work) in the aiming side rotation of the professional golf players were greater than those in the non-aiming side rotation, unlike the trunk rotation strength of the healthy controls. These findings are attributed to the repetitive practice of the professional golf players and their characteristics in a real game; and based on this asymmetry, further studies are required to investigate if trainings to strengthen the trunk rotation strength on the aiming side could influence golf performance.

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