©Journal of Sports Science and Medicine (2018) **17,** 492-500
http://www.jssm.org

Research article

Injuries among Korean Female Professional Golfers: A Prospective Study

Hee Seong Jeong [1,2,3], Young Moo Na [1,3], Sae Yong Lee [2,3] and Young Jae Cho [1,3]✉
[1] Department of Rehabilitation Medicine, SOL Hospital, Seoul, Republic of Korea; [2] Department of Physical Education, Yonsei University, Seoul, Republic of Korea; [3] Yonsei Institute of Sports Science and Exercise Medicine (YISSEM), Yonsei University, Seoul, Republic of Korea

Abstract
This study aims to analyze the incidence, location, type, and mechanisms of injuries and possible injury risk factors among all levels of Korean female professional golfers. This was a prospective study with a follow-up period of 24 months. A total of 363 members of the Korean Ladies Professional Golf Association (KLPGA), who competed in tournaments during the 2015 and 2016 seasons, took part in the study. The incidence of injury varied by tournament level and was significantly higher in Division II (11.1/1000AEs) and Division III (13.4/1000AEs) than in Division I (5.6/1000AEs) ($p < 0.05$). The most common location and type of injury were the shoulder/clavicle (Division I: 14.1%, Division II: 15.7%, Division III: 17.3%) and the tendinosis or tendinopathy (21.2%) (Division I: 23.7%, Division II: 21.2%, Division III: 18.5%), respectively. The most common mechanism of injury was the golf swing (47.9%–51.6% for the three divisions), and the most frequent specific phase of injury was upon ball impact (23.5%–30.9%). Multivariate analysis revealed that body mass index and the number of previous season competitions were significantly associated with injury risk in female golfers. The other factors examined did not have a significant association with golf-related injuries. In conclusion, KLPGA golfers were commonly exposed to injuries and showed a higher rate of injuries in competitions than practices, with significantly higher in Division II, III than Division I. However, overall, there was no significant difference in the location, type, mechanism and risk factors for injuries among the division level of KLPGA.

Key words: Golf, epidemiology, BMI, injury prevention, neuromuscular training.

Introduction

Golf is a popular sport worldwide, regardless of race, sex, age, or skill level (Cabri et al., 2009; McHardy et al., 2006; Sell et al., 2007). The global significance of golf was reinforced by this sport's inclusion in the 2016 Summer Olympics, the first time that golf was played at the Olympics since 1904 (Soligard et al., 2017).

There are many professional and amateur golfers in Korea. As of June 2017, the Korean Ladies Professional Golf Association (KLPGA) had 1,644 full members and 2,274 total members (KLPGA, 2017). Korean female professional golfers occupy more than half of the 15 top ranking in the Ladies Professional Golf Association (ROLEXRANKINGS, 2017). Unfortunately, the growing number of female golfers in Korea has been accompanied by a corresponding increase in golf-related injuries, many of which have been attributed to excessive training and competition beginning in childhood (Cabri et al., 2009; McGuffie et al., 1998; McLain and Reynolds, 1989).

According to epidemiological studies of the Olympic Games, golf was associated with a low injury risk—lower, for example, than BMX cycling or Taekwondo (Engebretsen et al., 2013; Grim et al., 2017; Junge et al., 2009; Soligard et al., 2017). However, golfers incur a large number of acute traumatic and overuse injuries, even though they are competing in a sport of noncontact with another player (Walsh et al., 2017).

Golf requires repetitive swinging in the same direction, and overuse of specific body parts because of excessive practice and competition can frequently result in inflammation and pain (Gosheger et al., 2003; McHardy et al., 2006). Although there have been many studies of injuries among professional and amateur golfers throughout the US and Europe, there exist few epidemiological studies of Asian professional golfers (McCarroll, 1996; McHardy et al., 2007; McHardy and Pollard, 2005). Preventing sports injuries and improving athletes' performance is an important goal of the International Olympic Committee (IOC) (Engebretsen et al., 2013; Soligard et al., 2015; Soligard et al., 2017). Epidemiological studies are necessary to understand the factors related to golfers' injuries and help in the development of programs that will prevent such injuries and enhance golf performance.

The purpose of the study sought to analyze the incidence, location, type, and mechanisms of injuries at the various levels of tournament play and to elucidate possible injury risk factors among Korean female professional golfers.

Methods

Participants

In total, 400 professional players took part in KLPGA tournaments during the 2015 and 2016 seasons, of which 363 golfers participated completely in this study. 119 golfers in Division I participated in this study, followed by 121 golfers in Division II and 123 golfers in Division III. The KLPGA tournaments were divided into three divisions. Division I, reserved for players with the highest ranking, held 31 tournaments per season in several different formats: three or four rounds of 18-hole stroke play (with only the top 60 players plus ties continuing to pay after the first two rounds) or gameplay. Divisions II and III had 19 and 16 tournament games per season, respectively, each of which consisted of two rounds of play (KLPGA, 2017). The study design was approved by the Yonsei University

Received: 18 April 2018 / Accepted: 30 July 2018 / Published (online): 01 September 2018

Institutional Review Board (IRB No. 7001988-201708-HR-245-04).

Data collection

We administered four surveys during the two seasons (each May and November). After filling out their scorecard upon finishing the day's round, golfers completed the Yonsei Institute of Sports Science and Exercise Medicine Injury Surveillance System (YISSEM ISS) survey of golf-related injuries under the supervision of athletic trainers. During the 6 months between surveys, the golfers were asked to note any golf-related injuries so that they could be recorded in the next survey.

Survey form

The 35-item YISSEM ISS questionnaire contains items from both the IOC and the United States National Collegiate Athletic Association (NCAA) Injury Surveillance System questionnaires (Dick et al., 2007; Engebretsen et al., 2012). It requests general information of relevance to female golfers: age, height, weight, body mass index (BMI), menstrual cycle, golf career, professional career, driving distance (i.e. official data by KLPGA), golf practice amount per day, and number of competitions during previous season (i.e. official data by KLPGA) (KLPGA, 2017). It also obtains information related to injuries (onset, acute or chronic, location, type, mechanisms, type of playing surface, and weather), and injury management and treatment questions (clinical exam, type of treatment and management, warmup, and stretching habits). Definition of injuries and illnesses were as new (i.e., pre-existing conditions were not recorded), or recurring musculoskeletal complaints, or other medical conditions (injuries) and or illnesses that occurred in competition and practice during the six months (Junge et al., 2009). Duplicate data on injuries and illnesses of a golfer were excluded. The YISSEM ISS questionnaire shows in Appendix 1.

Statistical analysis

We examined the impact of golf-related injury variables using univariate analysis and descriptive statistics. The injury rate was calculated per 1,000 athlete exposures (AEs) of practice or competition (game) (Soligard et al., 2017; Tuominen et al., 2017). The game AEs per golfer was calculated as 1 AEs per Day on the competition participated. The practice AEs per golfer was calculated by the number of rounding (9 or 18 holes) per week or, the number of practice golf swing (more than 1 box, assuming 100 balls per box) and or the number of physical training per day or week (Tuominen et al., 2017) (Refer to 7 in Appendix 1). Total AEs was added for 24 months period. Chi-square analysis was used to evaluate potential associations between injury information, injury management, and treatment at each level of the tournament. The analysis of risk factors for golf-related injuries applied a multivariate logistic regression model (Hosmer Jr et al., 2013). We calculated the odds ratios (OR) and the 95% confidence intervals (CI) to measure the strength of associations between each risk factor and injury information. All statistical analyses were performed using SPSS V.24.0 (IBM Corp, New York, USA). We regarded two-tailed p values of <0.05 as significant.

Results

Of the 400 Korean female professional golfers on tour during 2015 and 2016, overall 90.8% of golfers (n = 363) completed and returned their follow-up the YISSEM ISS questionnaire. 37 golfers were excluded from the study due to only one season attended or missing survey data, etc. The average age of total golfers was 22.3 years. On average height, weight and BMI of total golfers were 165.5 cm (SD 5.3), 59.7 kg (SD 6.7), and 21.9 kg/m^2 (SD 6.7). Total 9.9 years (SD 3.5) of golfers was golf career and 4.7 years (SD 3.0) of a professional career. The average driving distance of total golfers was 236.3 yards (SD 14.3). The normal menstruations of total golfers were 292 and 56 of hypomenorrhea (Table 1).

Table 1. Demographic and injury characteristics of KLPGA golfers.

Variables	Division I	Division II	Division III	Total
No. of survey (# of total athletes)	119 (144)	121 (128)	123 (128)	363 (400)
Age (years)	23.5 ± 3.4	22.4 ± 2.9	21 ± 3.2	22.3 ± 3.3
Height (cm)	166.1 ± 5.3	165.5 ± 5.2	165 ± 5.4	165.5 ± 5.3
Weight (kg)	60.8 ± 5.6	59.7 ± 6.0	58.7 ± 8.0	59.7 ± 6.7
Body mass index (kg/m2)	22.1 ± 1.7	21.9 ± 2.0	21.9 ± 2.0	21.9 ± 2.0
Golf career (years)	12.2 ± 2.6	10 ± 2.8	7.7 ± 2.7	9.9 ± 3.5
Professional career (years)	5.6 ± 5.6	4.5 ± 2.6	3.4 ± 2.7	4.7 ± 3.0
Driving distance (yards)	244.1 ± 10.2	235.4 ± 13.3	229.8 ± 15.3	236.3 ± 14.3
No. of normal menstruation	92	94	96	282
No. of hypomenorrhea	17	20	19	56
No. of primary amenorrhea	1	0	3	4
No. of secondary amenorrhea	7	7	4	18
No. of other menstruation	2	0	1	3
No. of overall Injuries	174	166	170	510
No. of game injuries	128	107	111	346
No. of practice injuries	127	133	133	393
Total No. of AEs-games	22 896	9 652	8 256	40 804
Total No. of AEs- practice	30 240	41 910	46 440	118 590
Injury rate/1000AEs-games	5.6	11.1	13.4	8.5
Injury rate/1000AEs-practice	4.2	3.2	2.9	3.3

Table 2. Location of injury in KLPGA golfers. Data are number (%).

	Division I	Division II	Division III	Total
Head and trunk	200 (31.3)	233 (35.5)	176 (32.8)	609 (33.2)
Face (including eye, ear, and nose)	13 (2.0)	28 (4.3)	13 (2.4)	54 (2.9)
Head	1 (0.2)	3 (0.5)	1 (0.2)	5 (0.3)
Neck/cervical spine	49 (7.7)	53 (8.1)	42 (7.8)	144 (7.9)
Thoracic spine/upper back	19 (3.0)	20 (3.0)	12 (2.2)	51 (2.8)
Sternum/ribs	9 (1.4)	8 (1.2)	8 (1.5)	25 (1.4)
Lumbar spine/lower back	73 (11.4)	78 (11.9)	67 (12.5)	218 (11.9)
Abdomen	0 (0)	1 (0.2)	1 (0.2)	2 (0.1)
Pelvis/sacrum/buttock	36 (5.6)	42 (6.4)	32 (6.0)	110 (6.0)
Upper extremities	230 (35.9)	272 (41.5)	244 (45.4)	746 (40.7)
Shoulder/clavicle	90 (14.1)	103 (15.7)	93 (17.3)	286 (15.6)
Upper arm	1 (0.2)	1 (0.2)	3 (0.6)	5 (0.3)
Elbow	20 (3.1)	31 (4.7)	28 (5.2)	79 (4.3)
Forearm	3 (0.5)	4 (0.6)	3 (0.6)	10 (0.5)
Wrist	78 (12.2)	86 (13.1)	79 (14.7)	243 (13.3)
Hand	13 (2.0)	16 (2.4)	13 (2.4)	42 (3.3)
Finger	10 (1.6)	14 (2.1)	13 (2.4)	37 (2.0)
Thumb	15 (2.3)	17 (2.6)	12 (2.2)	44 (2.4)
Lower extremities	210 (32.8)	151 (23.0)	117 (21.8)	478 (26.1)
Hip/groin	17 (2.7)	8 (1.2)	7 (1.3)	32 (1.7)
Thigh	9 (1.4)	5 (0.8)	3 (0.6)	17 (0.9)
Knee	62 (9.7)	41 (6.3)	34 (6.3)	137 (7.5)
Lower leg	14 (2.2)	7 (1.1)	5 (0.9)	26 (1.4)
Achilles tendon	24 (3.8)	18 (2.7)	13 (2.4)	55 (3.0)
Ankle	55 (8.6)	51 (7.8)	46 (8.6)	152 (8.3)
Foot/toe	29 (4.5)	21 (3.2)	9 (1.7)	59 (3.2)
Total	640	656	537	1833

Incidence of injury

A total of 510 injuries were recorded, of which injury rate of 8.5/1000AEs-games, and 3.3/1000AEs-practice ($p < 0.05$) (Table 1). Although reported total practice AEs was higher than the total game AEs, the injury rate per 1000 AEs-games was higher than one per 1000 AEs-practice. Of the 510 injuries (127.5 % of total athletes), 174 occurred in Division I (120.8 % of total athletes), 166 in Division II (129.7 % of total athletes), and 170 in Division III (132.8 % of total athletes). The injury rate per 1,000 AEs-games (competition) during the two seasons was significantly higher in Division II (11.1/1,000 AEs-games) and Division III (13.4/1,000 AEs-games) than in Division I (5.6/1,000 AEs-games) ($p < 0.05$). The total number of injuries per 1,000 AEs-practice during the two seasons was 3.3; on this statistic, higher rates were observed in Division I (4.2/1,000 AEs-practice) than in Division II (3.2/1,000 AEs-practice) or Division III (2.9/1,000 AEs-practice).

As noted above, Division I had 31 tournament games per year, of which 20 last for 3 days and 11 for 4 days. Divisions II and III had 19 and 16 2-day tournament games, respectively. A professional golfer requires 4–5 hour (h) to complete each round (i.e. 520 h in D I, 190 h in D II, and 160 h in D III per year, respectively). Division I golfers undergo approximately 6 h of golf training per competition day, division II golfers 7 h, and Division III golfers 7.5 h (i.e. golf training means a combination of warm-up, playing, post-round practice, etc.).

Location and type of injury

Overall, the most common injury location among KLPGA golfers was the upper extremities (40.7%), followed by the head and trunk (33.2%) and the lower extremities (26.1%) (Table 2). The relative prevalence of upper extremity injuries was greater in the lower divisions, especially Division III, whereas Division I had a higher percentage of lower extremity injuries. The shoulder/clavicle, wrist, lumbar spine/lower back, ankle, neck/cervical spine, and knee were common injury sites (Table 2).

The most common type of injury was the tendinosis/tendinopathy (21.2%), followed by ligament sprain (13.6%), meniscus lesions (11.2%), muscle strain, rupture, or tear (9.1%), and inflammation of unknown cause (7.0%) (Table 3). There were no statistically significant differences by tournament division.

Mechanism of injury

As shown in Figure 1, the most common mechanism of injury was the golf swing (49.8% of total), followed by physical training (20.6% of total), noncontact trauma (11.9% of total), and contact with another object (6.8% of total). The noncontact trauma category included noncontact swing motion or overuse. Contact with other objects includes being hit by a golf ball or cart as well as contact with the playing ground. The most common injury phase was at ball impact (26.5%), followed by the downswing (11.4%), backswing (11.1%), finish (10.7%), and follow-through (10.3%) (Figure 2). Also, 8.1% and 6.2% of injuries occurred during walking or running, respectively.

The lower-level golfers more frequently reported not knowing how they had injured themselves, reflected as "unsure" item responses. Most injuries were reportedly sustained during morning warmups (32%) or after golf rounds (29%), and during the first day of competition in each tournament (50%) of the season. During in-season and off-season activity, more injuries occurred during

Table 3. Types of injuries in KLPGA golfers. Data are umber (%).

	Division I	Division II	Division III	Total
Tendinosis or tendinopathy	74 (23.7)	66 (21.2)	52 (18.5)	192 (21.2)
Sprain (joint or ligaments)	45 (14.4)	38 (12.2)	40 (14.2)	123 (13.6)
Meniscus or cartilage lesions	30 (9.6)	34 (10.9)	37 (13.2)	101 (11.2)
Strain, muscle rupture, or tear	33 (10.6)	26 (8.3)	23 (8.2)	82 (9.1)
Inflammation (unknown cause)	25 (8.0)	21 (6.7)	17 (6.0)	63 (7.0)
Contusion, hematoma, or bruise	21 (6.7)	15 (4.8)	21 (7.5)	57 (6.3)
Arthritis, synovitis, or bursitis	13 (4.2)	15 (4.8)	13 (4.6)	41 (4.5)
Fasciitis, aponeurosis injury	12 (3.8)	11 (3.5)	11 (3.9)	34 (3.8)
Nerve or spinal cord injury	10 (3.2)	6 (1.9)	18 (6.4)	34 (3.8)
Muscle cramps or spasm	5 (1.6)	11 (3.5)	11 (3.9)	27 (3.0)
Stress fracture (overuse)	7 (2.2)	11 (3.5)	5 (1.8)	23 (2.5)
Laceration, abrasion, or skin lesion	5 (1.6)	9 (2.9)	3 (1.1)	17 (1.9)
Other bone injuries	6 (1.9)	3 (1.0)	6 (2.1)	15 (1.7)
Fracture	4 (1.3)	4 (1.3)	5 (1.8)	13 (1.4)
Ligamentous rupture	4 (1.3)	4 (1.3)	4 (1.4)	12 (1.3)
Tendon rupture	1 (0.3)	5 (1.6)	2 (0.7)	8 (0.9)
Dental injury, broken tooth	0 (0.0)	7 (2.2)	1 (0.4)	8 (0.9)
Dislocation, subluxation	1 (0.3)	3 (1.0)	1 (0.4)	5 (0.6)
Concussion	0 (0.0)	1 (0.3)	1 (0.4)	2 (0.2)
Other	16 (5.1)	22 (7.1)	10 (3.6)	48 (5.3)
Total	312	312	281	905

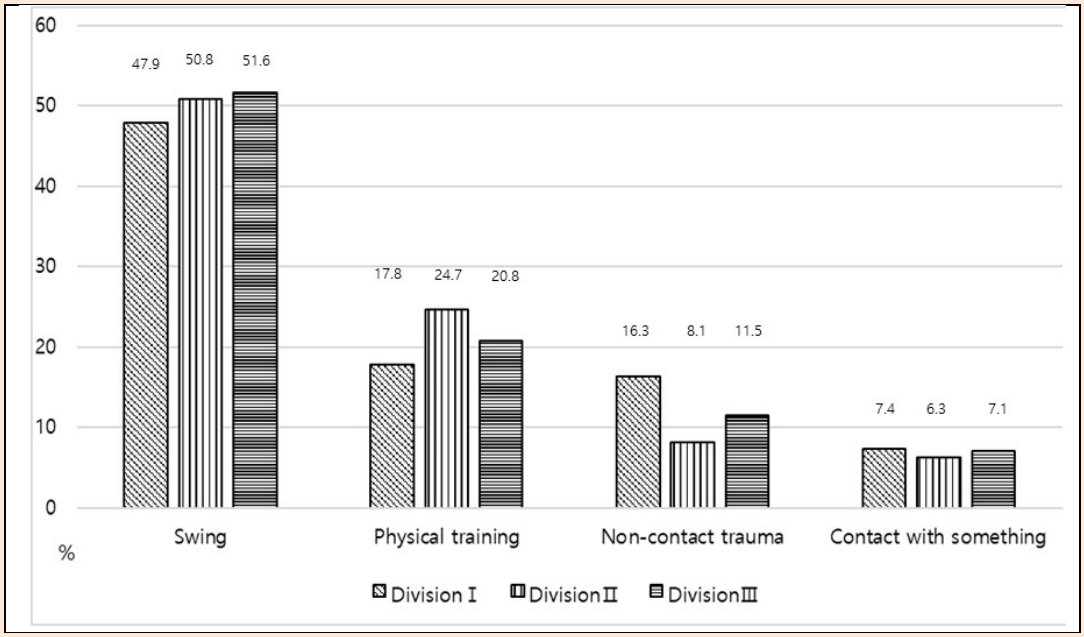

Figure 1. Mechanisms of injury in KLPGA.

the golf swing, typically on artificial turf (34.3%), bare ground and urethane track (28%) (i.e., at walking or warm-up swing in golf course), or poor turf (20.1%) than on natural turf in normal condition (17%) (Figure 3).

Risk factors for golf injuries

Those who played in Division I were more likely to be injured (OR = 1.603, 95% CI: 0.914–2.812) than those in Divisions II and III (Table 4). Golfers with BMI of 30–35 were most likely to sustain an injury (OR = 2.920, 95% CI: 1.096–7.779, $p < 0.032$), whereas those with BMI <18.5 were least likely to sustain an injury (OR = 0.121, 95% CI: 0.021–0.693, $p < 0.018$). Although the difference was not statistically significant, golfers with longer driving distance had a higher risk of golf injuries (OR = 2.378, 95% CI: 0.714–7.920, $p > 0.158$). Golfers who participated in 10–19 tournament games during the previous season were more likely to sustain an injury (OR = 2.845, 95% CI: 1.672–4.842, $p < 0.000$) than those who competed in ≤9 matches. Those who had played 20 or more tournament games in the previous season were also more likely to be injured than those playing ≤9 times, but the difference did not rise to the level of statistical significance (OR = 1.246 for 20–29 tournament games, OR = 1.233 for ≥30 tournament games). Other potential factors for golf-related injuries did not exhibit statistically significant between-group differences.

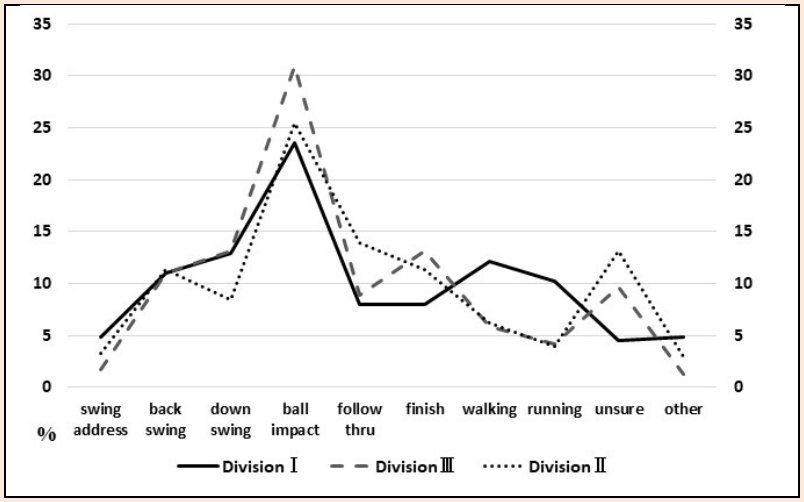

Figure 2. Injury phases in KLPGA.

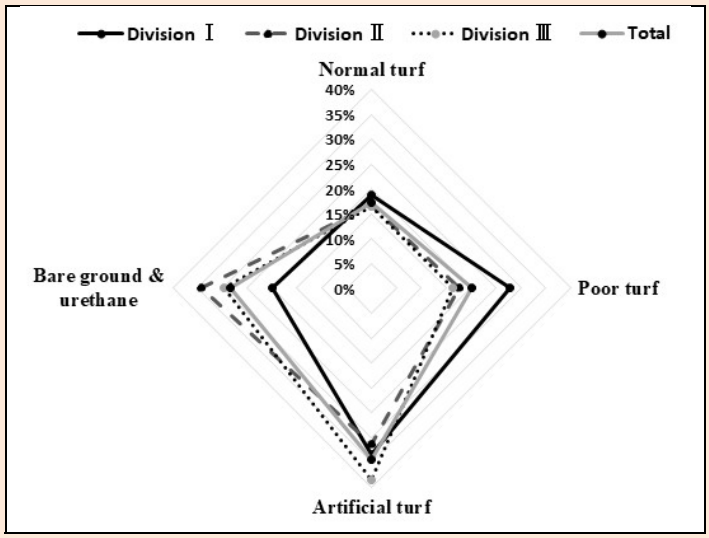

Figure 3. Ground status at time of injury in KLPGA.

Table 4. Summary of results from the multivariate analysis.

Variable	*p*-value	Odds ratio	95% CI for true OR*	
			Lower	Upper
Levels of golf play (Division III)	.090			
Division II	.848	.953	.586	1.552
Division I	.100	1.603	.914	2.812
Body Mass Index (18.5≤BMI<23)	.029			
BMI <18.5	.018	.121	.021	.693
23 ≤ BMI < 25	.602	.884	.557	1.404
25 ≤ BMI < 30	.032	2.920	1.096	7.779
30 ≤ BMI < 40	1.000	1.3119	.000	-
Driving distance (0–209 yards)	.089			
210–219	.881	1.105	.298	4.093
220–229	.914	1.070	.315	3.638
230–239	.158	2.378	.714	7.920
240–249	.715	1.248	.380	4.096
250–259	.989	.991	.296	3.320
>260	.918	.931	.242	3.358
No. of competitions in previous season (0–9)	.001			
10–19	.000	2.845	1.672	4.842
20–29	.385	1.246	.758	2.047
> 30	.365	1.233	.539	5.365

* OR (95% CI) = Odds ratio (95% confidence interval)

Discussion

The main findings showed that KLPGA golfers, regardless of their tournament division level, were most likely to occur shoulder/clavicle body parts, type of injuries like the tendinosis or tendinopathy, and or ligament sprains, and mechanism of injuries such as overuse and ball impact during the golf swing. Risk factors for golf injuries were BMI, and the number of tournament games played in the previous season. These findings have implications for preventing injury in KLPGA and for managing and treating injuries, as well as for supporting golfers' preparations for competition.

Injury characteristics in the professional female golfer

Among the professional female golfers in this study, the most common injury location was the shoulder/clavicle, followed by the wrist, lower back, ankle, and neck. In previous studies of female professional golfers, the most common location of injury was the wrist, followed by the lower back and the hand (McCarroll and Gioe, 1982). Sugaya and his colleagues reported that injuries to the lower back were most frequent, followed by the neck, elbow, and shoulder injuries (Sugaya et al., 1999). According to the Gosheger et al. in their study, the common injury site of male professional golfers were the lower back, wrist and shoulder, and that of male amateur golfers were the elbow, lower back and shoulder (Gosheger et al., 2003). Additionally, a study by McHardy et al. reported that male and female amateur golfers were the lower back to be the site of most injuries, followed by elbow/forearm, foot/ankle, and shoulder (McHardy et al., 2007).

Our study was unique in finding that the shoulder/clavicle was the most frequent injury location in this group of elite and semi-elite golfers. The reason for this finding appears to be overuse of the shoulder, which can produce pain and instability as a result of excessive loading during training and competition (Gosheger et al., 2003; Kim et al., 2004) or playing in many tournament games (McHardy et al., 2006). About shoulder movement of the golf swing in elite and semi-elite golfer of all, from the address to the top of the backswing phase, the left shoulder (for a right-handed golfer) adducts horizontally, and the right shoulder rotates externally. In the segment from the downswing to the follow-through phase, the left shoulder rotates externally and abducts, and the right shoulder adducts horizontally (Mitchell et al., 2003). Bell reported that the movement that produced the maximum force across the acromioclavicular joint was horizontal adduction and abduction (Bell R and Noe, 1993). However, a study by Hovis et al. described that posterior glenohumeral instability of elite golfers might cause the pain and injuries in the shoulder (Hovis et al., 2002). Therefore, injuries to the shoulder may be associated with repetitive, excessive loading of the acromioclavicular joint and anterior-posterior glenohumeral instability during golf swings. The upper extremities and the head and trunk sustained greater frequency of injury than the lower extremities.

Wrist injuries in golfers are more likely to occur at the impact phase of the golf swing, as the clubhead makes contact with the golf ball or possibly with objects such as rough turf, urethane track and bare ground (i.e., at walking or warm-up swing in golf course) (Ek et al., 2013; A. McHardy et al., 2006). Also, golfers constantly experience wrist impact because of the magnitude of grip force control required for the downswing phase (McHardy et al., 2006; Pluim et al., 2006).

Common causes of lower back injuries in golfers are the mechanics of the golf swing and overuse during practice (Cabri et al., 2009). Considerable forces are generated as a result of the mechanics of the powerful downward compression during the golf swing, lateral bending, and peak shear loads (Hosea, 1990).

The present study found that the most common injury type was the tendinosis or tendinopathy, followed by sprains, meniscus lesions, strains and inflammation of unknown cause. KLPGA golfers appear similar to those described in previous studies of injuries related to overuse from swing practice and physical training (Cabri et al., 2009; Gosheger et al., 2003; McHardy et al., 2006; 2007).

Mechanisms of injury

Overall, the most common mechanism leading to injury was the golf swing. This result was similar to those of previous studies (Batt, 1992; McCarroll and Gioe 1982; McCarroll et al., 1990). The most common phase of injury during the golf swing was at ball impact, followed by the downswing and backswing. In general, golfers consistently try to execute their best golf swing to send the ball to a certain position on the golf course (Cabri et al., 2009). When hitting from the tee, golfers usually seek to maximize distance (Cabri et al., 2009; McHardy et al., 2006). To do so, they produce very powerful movements with the back, shoulders, arms, hips and lower extremities. Previous studies have described changes in the clubhead speed, in the club shaft and head material, and in modern golf swing techniques (referred to as the dynamic X-factor), all designed to further maximize distance (Cabri et al., 2009; Lindsay et al., 2000; McHardy et al., 2007; Worobets and Stefanyshyn, 2007).

Many golfers in KLPGA appear to have practiced excessive swings for maximum distance. Common injury times were morning practice, during golf swings on less than desirable ground. It has been reported that golfers' injuries are related to overuse (80%), hitting a behind the ball (12%), and twisting the trunk during the golf swing (5%). Other reasons included poor swing mechanics, hitting the ground, and being hit by a ball (Cabri et al., 2009; McCarroll, 1996). The main reason for injuries to the shoulders, wrists, and low back in KLPGA may be repeated golf swings while practicing from a non-ideal hitting surface and or some cumulative fatigue for overuse of golf swing (McHardy et al., 2006; Purevsuren et al., 2017).

Notably, a substantial number of injuries occurred during walking or running on the golf course. Golfers walk approximately 8–10 km during an 18-hole event while taking 4–5 h to play a standard round. Also, they endure long exposure to the sun and rain during summer (McHardy et

al., 2006). As a result, golfers, once fatigued, may suffer an ankle injury by stumbling over a rock or on grass, or while walking or running the course with fellow competitors. Therefore, the number of the golf swing and the long-term outdoor exposure are associated with some cumulative fatigue damage (Higdon et al., 2012; Purevsuren et al., 2017); it may be an important risk factor of the golf injury.

Other than injuries related to golf swings, injuries in Division I tended to occur secondary to noncontact traumas, whereas Divisions II and III exhibited high numbers of injuries caused by physical training. Perhaps progressive injuries may result from the aversive habits in which many KLPGA members may engage, such as excessive physical training leading to chronic pain that is not treated properly.

Risk factors for injury

BMI and the number of competitions in previous season matches were significantly associated with increased risk of injury. As mentioned earlier, BMI, the number of matches games and pre-existing injuries are related to some cumulative fatigue of golfers, so it may be evidence that a golfer with moderate BMI has a lower risk of injury than a high BMI. The normal range of BMI for Koreans is 18.5–25; BMI of <18.5 is underweight, 25–30 is considered overweight, and >30 is obese (KCDC, 2016). Overall, the average BMI among KLPGA players was 21.9 ± 2.0 $kg \cdot m^{-2}$. Many golfers are gaining weight to increase their driving distance. They believe that to improve their power have to gain both weight and muscle mass (Hulens et al., 2001). But, the previous study suggested that an increase in swing speed as a result of gaining weight and physical training may be related to golf injuries (Hellström, 2002). Also, a study by Evans et al. reported that elite golfers with BMI<25.7 appeared to be more frequent episodes of moderate-severe low back pain. Therefore, although the high BMI may not be safe to an injury, our colleagues recommend that the neuromuscular and proprioceptive training could be to prevent an injury for the lower back, shoulder, and knee joint, even in normal BMI (Hoogenboom et al., 2014).

Although there was no statistically significant difference between the average distance and injury risk, we found that having an average driving distance of 210–249 yards appeared to increase injury risk somewhat, but golfers with an average driving distance of 250 yards or more did not have an increased injury risk in this study. The overall average driving distance of KLPGA players was 236.3 ± 14.3 yards. If both driving distance and BMI were high, there was a greater risk of injury.

Women who had played between 10 and 19 KLPGA tournament games in the previous season were more likely to suffer a golf injury than that those who had played <10 tournament games (OR = 2.845, $p = 0.001$). That may be because golfers who had played between 10 and 19 KLPGA tournament games were a lot in Divisions II and III. Therefore, it cannot be sure that golf injury would be high due to playing a lot of tournament games in the previous season. More research is needed to whether the number of competition in the previous season is a risk factor of golf injury or not.

Efforts to prevent golf injuries

Although the interest in preventing and treating golf-related injuries was very high (82.5%), only 59% of golfers reported being treated within 1 week for their injuries, and 37.6% remained untreated after 10 days. The reasons given for not accessing timely treatment included being ‘busy’ (43.7%), ‘I don’t know’ (19.7%), ‘so tired’ (18.2%), and other (18.4%). Left untreated, golf-related injuries can worsen and become chronic, as many golfers participate in competitions and practice with injuries and pain for prolonged periods of time. In addition, 50.9% of golfers reported participating in competition within 7 days of recovery from an injury. Also, 73% of total golfers reported performing warm-up and stretching for injury prevention and treatment, followed by physical training (60%), physical therapy (52%), and rehabilitation (36%) (Refer to 33, 34 in Appendix 1). Therefore, evidence-based practice guidelines suggest that golfers to prevent injuries should consider weight control, or neuromuscular and proprioceptive training to improve the functional stability of the shoulder, lumbar and wrist joint, or the number of tournament games in which the athlete competes (Hoogenboom et al., 2014).

Strengths and limitations of the study

One important strength of this study was the large cohort of professional female golfers who completed surveys over the two-season study period. The professional athletes’ very high response rates (90.7% of total golfers) in the midst of a tournament activity indicated a strong concern for the topic. One limitation of the study was that surveys were administered in tournament settings only and not in practice or training settings. There was a potential recall bias because the golfers were asked to think about the injuries they had suffered in the previous 6 months. We cloud not collect data on golfer’s prior history of injury and other sports activities. Also, the number of athlete exposures was estimated on the basis of the number of games played in competitive tournaments or the number of training in practice, because individual’s on-course exposure could not be feasibly measured.

Conclusion

KLPGA golfers were frequently exposed to injuries and showed a higher rate of injuries in competitions than practices, with significantly higher in Division II and III than in Division I during two seasons. However, there was no significant difference in the location, type, mechanism and risk factors for injuries among the division level of KLPGA. Overall, the most common injury location, type, and mechanism among KLPGA golfers were the shoulder/clavicle, and the tendinosis/tendinopathy, and the ball impact of the golf swing. Also, the risk factors for injury were BMI, and the number of tournament games played in the previous season. Finally, through continuous prospective cohort study of KLPAG players, as well as KPGA and amateur players in the future should provide an injury prevention programs and guidelines for chronic injury management evidence-based on risk factors of injury golf.

Acknowledgements

The authors wish to thank all golfers in KLPGA for their participation in this study. We deeply appreciate the cooperation of all team physicians, as well as YISSEM and SOL hospital medical supervisors who volunteered to collect the data for this project. We also thank the Korea Ladies Professional Golf Association for its practical assistance. This project was financially supported by the Yonsei Institute of Sports Science and Exercise Medicine (YISSEM 2015-51-0455), which is an International Research Centre for Prevention of Injury and Protection Athlete Health supported by the International Olympic Committee (IOC). The experiments comply with the current laws of the country in which they were performed. The authors have no conflict of interest to declare.

References

Batt, M.E. (1992) A survey of golf injuries in amateur golfers. *British Journal of Sports Medicine* **26(1),** 63-65.

Bell R, A.R., Noe D. (1993) A study of acromioclavicular forces. *Journal of Shoulder and Elbow Surgery* **2(Suppl .1-2),** s24.

Cabri, J., Sousa, J.P., Kots, M. and Barreiros, J. (2009) Golf-related injuries: A systematic review. *European Journal of Sport Science* **9(6),** 353-366.

Dick, R., Agel, J. and Marshall, S.W. (2007) National Collegiate Athletic Association injury surveillance system commentaries: introduction and methods. *Journal of Athletic Training* **42(2),** 173.

Ek, E.T., Suh, N. and Weiland, A.J. (2013) Hand and wrist injuries in golf. *The Journal of Hand Surgery* **38(10),** 2029-2033.

Engebretsen, L., Soligard, T., Steffen, K., Alonso, J. M., Aubry, M., Budgett, R., Dvorak, J., Jegathesan, M., Meeuwisse, W.H., Mountjoy, M., Palmer-Green, D., Vanhegan, I. and Renstrom, P. A. (2013) Sports injuries and illnesses during the London Summer Olympic Games 2012. *British Journal of Sports Medicine* **47(7),** 407-414.

Engebretsen L, S.T., Steffen, K., Renström, P., Alonso, J.M., Aubry, M., Dvorak, J., Meeuwisse, W., Mountjoy, M., Palmer-Green, D. and Vanhegan, I. (2012) *London 2012 Olympic Summer Games Injury and Illness Surveillance Study*. International Olympic Committee, Lausanne.

Gosheger, G., Liem, D., Ludwig, K., Greshake, O. and Winkelmann, W. (2003) Injuries and overuse syndromes in golf. *The American Journal of Sports Medicine* **31(3)**, 438-443.

Grim, C., Hotfiel, T., Engelhardt, M., Plewinski, S., Spahl, O. and Wolfarth, B. (2017) Sports Injuries and Illnesses of the German National Team during the 2016 Olympic Summer Games in Rio de Janeiro. *Sportverletzung Sportschaden* **31(1),** 25-30.

Hellström, J. (2002) Strength training and injury prevention for professional golfers In *Science and golf IV: Proceedings of the world scientific congress of golf, St Andrews, Jul*. 64-76.

Higdon, N. R., Finch, W. H., Leib, D. and Dugan, E. L. (2012) Effects of fatigue on golf performance. *Sports Biomechanics* **11(2),** 190-196.

Hoogenboom, B.J., Voight, M.L. and Prentice, W.E. (2014) *Musculoskeletal interventions: techniques for therapeutic exercise. Third edition*. McGraw-Hill New York, NY.

Hosea, T. (1990) Biomechanical analysis of the golfer's back. *Science and golf*: 43-48.

Hosmer Jr, D.W., Lemeshow, S. and Sturdivant, R.X. (2013) *Applied logistic regression*. John Wiley & Sons.

Hovis, W.D., Dean, M.T., Mallon, W.J. and Hawkins, R.J. (2002) Posterior instability of the shoulder with secondary impingement in elite golfers. *The American Journal of Sports Medicine* **30(6),** 886-890.

Hulens, M., Vansant, G., Lysens, R., Claessens, A., Muls, E. and Brumagne, S. (2001) Study of differences in peripheral muscle strength of lean versus obese women: an allometric approach. *International Journal of Obesity* **25(5),** 676.

Junge, A., Engebretsen, L., Mountjoy, M. L., Alonso, J. M., Renstrom, P. A., Aubry, M. J. and Dvorak, J. (2009) Sports injuries during the Summer Olympic Games 2008. *The American Journal of Sports Medicine* **37(11),** 2165-2172.

KCDC. (2016) Korea Health Statistics 2015 : Korea National Health and Nutrition Examination Survey. Korea Centers for Disease Contro & Prevention. 49.

Kim, D.H., Millett, P.J., Warner, J.J. and Jobe, F.W. (2004) Shoulder injuries in golf. *The American Journal of Sports Medicine* **32(5),** 1324-1330.

KLPGA. (2017) *KLPGA Membership Status*. Available from URL: https://klpga.co.kr/ Accessed June 12, (2017).

Lindsay, D.M., Horton, J.F. and Vandervoort, A.A. (2000) A review of injury characteristics, aging factors and prevention programmes for the older golfer. *Sports Medicine (Auckland, N.Z.)* **30(2),** 89-103.

McCarroll, J. and Gioe, T.J. (1982). Professional golfers and the price they pay. *The Physician and Sportsmedicine* **10,** 64-70.

McCarroll, J.R. (1996) The frequency of golf injuries. *Clinics in Sports Medicine* **15(1),** 1-7.

McCarroll, J.R., Rettig, A.C. and Shelbourne, K.D. (1990) Injuries in the amateur golfer. *The Physician and Sportsmedicine* **18(3),** 122-126.

McGuffie, A.C., Fitzpatrick, M.O. and Hall, D. (1998) Golf related head injuries in children: the little tigers. *Scottish Medical Journal* **43(5),** 139-140.

McHardy, A., Pollard, H. and Luo, K. (2006) Golf injuries: a review of the literature. *Sports Medicine (Auckland, N.Z.)* **36(2),** 171-187.

McHardy, A., Pollard, H. and Luo, K. (2007) One-year follow-up study on golf injuries in Australian amateur golfers. *The American Journal of Sports Medicine* **35(8),** 1354-1360.

McHardy, A.J. and Pollard, H.P. (2005). Golf and upper limb injuries: a summary and review of the literature. *Chiropractic & Osteopathy* **13**: 7.

McLain, L. G. and Reynolds, S. (1989) Sports injuries in a high school. *Pediatrics* **84(3),** 446-450.

Mitchell, K., Banks, S., Morgan, D. and Sugaya, H. (2003) Shoulder motions during the golf swing in male amateur golfers. *The Journal of Orthopaedic and Sports Physical Therapy* **33(4),** 196-203.

Pluim, B.M., Staal, J.B., Windler, G.E. and Jayanthi, N. (2006) Tennis injuries: occurrence, aetiology, and prevention. *British Journal of Sports Medicine* **40(5),** 415-423.

Purevsuren, T., Kwon, M.S., Park, W.M., Kim, K., Jang, S.H., Lim, Y.-T. and Kim, Y.H. (2017) Fatigue injury risk in anterior cruciate ligament of target side knee during golf swing. *Journal of Biomechanics* **53,** 9-14.

ROLEXRANKINGS. (2017) *Overview Rankings, Women's World Golf Rankings.* Available from URL: http://www.rolexrankings.com/ Accessed October 10, (2017).

Sell, T.C., Tsai, Y.S., Smoliga, J.M., Myers, J.B. and Lephart, S.M. (2007) Strength, flexibility, and balance characteristics of highly proficient golfers. *Journal of Strength and Conditioning Research* **21(4),** 1166-1171.

Soligard, T., Steffen, K., Palmer-Green, D., Aubry, M., Grant, M.-E., Meeuwisse, W., Mountjoy, M., Budgett, R. and Engebretsen, L. (2015) Sports injuries and illnesses in the Sochi 2014 Olympic Winter Games. *British Journal of Sports Medicine* **49(7),** 441-447.

Soligard, T., Steffen, K., Palmer, D., Alonso, J. M., Bahr, R., Lopes, A. D., Dvorak, J., Grant, M.-E., Meeuwisse, W. and Mountjoy, M. (2017) Sports injury and illness incidence in the Rio de Janeiro 2016 Olympic Summer Games: A prospective study of 11274 athletes from 207 countries. *British Journal of Sports Medicine* **51(17),** 1265-1271.

Sugaya, H., Tsuchiya, A., Moriya, H., Morgan, D. and Banks, S. (1999) Low back injury in elite and professional golfers: an epidemiologic and radiographic study In: *Proceedings of the World Scientific Congress of Golf Science & Golf Ill: 20–24 July 1998; St. Andrews*. 83-91.

Tuominen, M., Hänninen, T., Parkkari, J., Stuart, M.J., Luoto, T., Kannus, P. and Aubry, M. (2017) Concussion in the international ice hockey World Championships and Olympic Winter Games between 2006 and 2015. *British Journal of Sports Medicine* **51(4),** 244-252.

Walsh, B.A., Chounthirath, T., Friedenberg, L. and Smith, G.A. (2017) Golf-related injuries treated in United States emergency departments. *The American Journal of Emergency Medicine* **35(11),** 1666-1671.

Worobets, J. and Stefanyshyn, D. (2007) Shaft stiffness significantly influences golf clubhead speed at impact. *Journal of Biomechanics* **40(2),** S279.

Key points

- The incidence of injury was different according to the level of tournament plays in female professional golfer and higher in the low group of tournament play.
- The most common location and type of injury in KLPGA were the shoulder/clavicle and tendinosis/tendinopathy respectively.
- The most common mechanism of injury in KLPGA was due to the golf swing, and the most frequent specific phase of injury was upon ball impact.
- Risk factors for injury in KLPGA were BMI, and the number of tournament games played in the previous season.

AUTHOR BIOGRAPHY

Hee Seong JEONG
Employment
Department of Rehabilitation Medicine, SOL Hospital
Degree
MSc
Research interests
Sports rehabilitation, Injury prevention and performance improvements in sport, Sports biomechanics
E-mail: jhees0416@gmail.com

Young Moo NA
Employment
Department of Rehabilitation Medicine, SOL Hospital
Degree
MD, PhD
Research interests
Sports rehabilitation, Sports medicine
E-mail: solspo@naver.com

Sae Yong LEE
Employment
Department of Physical Education,
Yonsei University
Degree
PhD, ATC
Research interests
Sports rehabilitation, Sports biomechanics, Injury prevention and performance improvements in sport
E-mail: issrl2012@gmail.com

Young Jae CHO
Employment
Department of Rehabilitation Medicine, SOL Hospital
Degree
PhD
Research interests
Sports rehabilitation, Sports biomechanics
E-mail: cyjjyc94@hanmail.net

✉ **Young Jae Cho, PhD**
Department of Rehabilitation Medicine, SOL Hospital, 352, Banghwa-daero, Gangseo-gu, Seoul, 07592, Republic of Korea