



Epidemiology of Achilles Tendon Rupture in South Korea: Claims Data of the National Health Insurance Service from 2009 to 2017

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Background: The incidence of Achilles tendon rupture and its trend has not been studied in Asia. The purpose of this nationwide study was to analyze the trend of incidence and surgical treatment of tendon ruptures in South Korea based on sex, age, and income level of patients, as well as seasonal variation.

Methods: A descriptive epidemiologic study was performed based on the data collected retrospectively from the Korea National Health Insurance Service. Data of all outpatients and inpatients were collected from approximately 52 million residents of South Korea, primarily diagnosed with Achilles tendon rupture from 2009 to 2017.

Results: A total of 112,350 patients had Achilles tendon rupture, of which 44,248 patients underwent surgical treatment during the study period. The overall, age-specific, and sex-specific incidence of Achilles tendon rupture and surgical treatment showed an increasing trend. Patients in the age group of 41 to 50 years showed the highest increase in incidence. Regarding season, higher incidence was reported during spring and summer, whereas the lowest incidence was found in winter. Higher income level was associated with increased incidence of the condition.

Conclusions: The incidence of Achilles tendon rupture and surgical treatments increased rapidly in patients between 41 and 50 years of age. Patients in the higher income quintile groups experienced more Achilles tendon injury than those in lower income groups, and fewer ruptures were observed during winter.

Keywords: *Achilles tendon, Tendon injuries, Rupture, Incidence*

The incidence of Achilles tendon rupture has shown an increasing trend in many studies since it was first reported in 1976.¹⁾ Recent studies have reported that the increasing trend was most evident in older age groups, while the highest incidence was seen in patients between 30 and 50 years of age.²⁻⁶⁾ Patients commonly sustain the injury while

playing sports such as badminton, soccer, or basketball^{2,4,5)} and it is more common in men than women.³⁻⁶⁾ Recent population-based studies have strengthened the available data on Achilles tendon rupture by utilizing larger databases and further evaluating factors such as geographical variation and seasonality.^{2,3,5,6)} To the best of our knowledge, previous epidemiologic studies have been conducted in European and North American countries; therefore, little is known regarding the incidence of the injury in Asia. The purpose of this nationwide study, as a first attempt to investigate the condition in Asia, was to analyze the trend of incidence and surgical treatment of Achilles tendon rupture in South Korea from 2009 to 2017 based on sex, age, and income level of the patients, as well as seasonal variation.

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METHODS

The Institutional Review Board of Gachon University Gil Medical Center approved this study (IRB No. GCIRB2019-270), and the requirement for written informed consent was waived.

This descriptive and retrospective study was based on the database of the Korea National Health Insurance Service (KNHIS), which covers the entire population. Enrolment in the KNHIS is mandatory for all South Koreans residing in different territories since its establishment in July 2000, following the National Health Insurance Act in February 1999. However, individuals with low income who are covered by the Medical Aid program provided by the government are exempted from enrolment in the KNHIS. As of 2013, 97.2% of the population were covered by health insurance, and the remaining 2.8% were covered by the Medical Aid program. The KNHIS database consists of qualification and contribution data (sex, age, region, and income among others.) and health insurance claims data (diagnosis, surgery performed, medical costs, and the

medical service used).⁷⁾ In this study, the observation period was 9 years (2009–2017) after excluding a washout period of 2 years (2007–2009). Monthly data were collected of outpatients and inpatients with diagnostic code of S86.0 of Korean classification of disease, 7th revision, which is primarily constructed based on Classification of Diseases, 10th revision of the World Health Organization. It represents the Achilles tendon injury, including subgroups of S86.00 and S86.08, which is specified in the form of injury as laceration and other and unspecified injuries to isolate all potential cases. A total of 112,350 cases were selected, and then the variables provided with a designated code by KNHIS were used in our statistics. The variables and codes used were sex (SEX_TYPE), birth of year (BYEAR), status of income quintile group (CALC_CTRB_VTILE_FD), date of diagnosis (MDCARE_START_DT), and status of surgery (OPRTN_YN). For statistical analysis, the incidence of Achilles tendon ruptures and surgical treatment was calculated per 100,000 person-years based on the annual figures provided by the Korean National Statistical Office. The 95% confidence interval was not computed because the data were based on the entire population of

Table 1. Incidence of Achilles Tendon Rupture (per 100,000 Person-Years) by Sex

Variable	2009	2010	2011	2012	2013	2014	2015	2016	2017	Annual increase	p-value
Total	20.75	21.39	24.04	23.83	24.95	24.82	26.63	26.93	26.53	1.032	< 0.001*
Sex											0.779 [†]
Male	29.23	30.22	33.37	33.57	34.89	35.12	37.39	37.7	37.76	1.033	
Female	12.25	12.52	14.68	14.06	14.98	14.51	15.88	16.18	15.33	1.03	

*The p-value of annual increasing trend in a model without an interaction effect. [†]The p-value of interaction effects between annual increasing trend and subgroups.

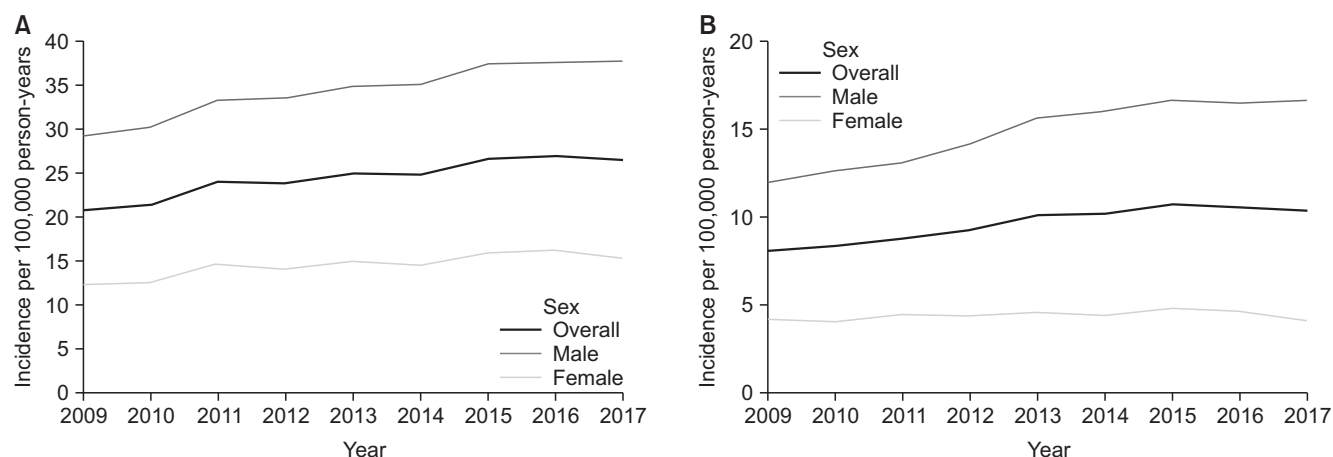


Fig. 1. (A) Trend in incidence of Achilles tendon rupture (per 100,000 person-years) by sex. (B) Trend in incidence of surgical treatment of Achilles tendon rupture (per 100,000 person-years) by sex.

Table 2. Incidence of Surgical Treatment of Achilles Tendon Rupture (per 100,000 Person-Years) by Sex

Variable	2009	2010	2011	2012	2013	2014	2015	2016	2017	Annual increase	p-value
Total	8.10	8.37	8.79	9.29	10.13	10.22	10.74	10.57	10.38	1.037	< 0.001*
Sex											0.003 [†]
Male	11.97	12.65	13.10	14.17	15.65	16.01	16.65	16.50	16.66	1.027	
Female	4.21	4.06	4.47	4.39	4.59	4.42	4.82	4.66	4.12	1.008	

*The p-value of annual increasing trend in a model without an interaction effect. [†]The p-value of interaction effects between annual increasing trend and subgroups.

Table 3. Incidence of Achilles Tendon Rupture (per 100,000 Person-Years) by Age

Age (yr)	2009	2010	2011	2012	2013	2014	2015	2016	2017	Annual increase	p-value
Total	20.75	21.39	24.04	23.83	24.95	24.82	26.63	26.93	26.53	1.035	< 0.001*
Age group											0.064 [†]
1–20	14.89	15.69	20.16	18.48	18.33	18.96	19.91	20.18	19.52	1.030	
21–30	16.50	18.65	21.30	21.88	23.55	23.91	25.57	26.35	24.89	1.051	
31–40	29.29	29.48	31.81	30.93	32.76	33.12	35.55	35.16	35.56	1.027	
41–50	30.65	31.00	33.87	34.79	39.08	38.11	40.52	41.33	41.29	1.042	
51–60	22.20	22.56	24.63	24.99	24.22	24.39	27.35	26.97	27.94	1.028	
61–70	13.89	13.84	15.53	15.20	15.85	15.75	17.27	18.34	17.89	1.036	
> 71	8.56	8.94	9.02	10.54	10.60	9.23	10.60	12.02	10.86	1.034	

*The p-value of annual increasing trend in a model without an interaction effect. [†]The p-value of interaction effects between annual increasing trend and subgroups.

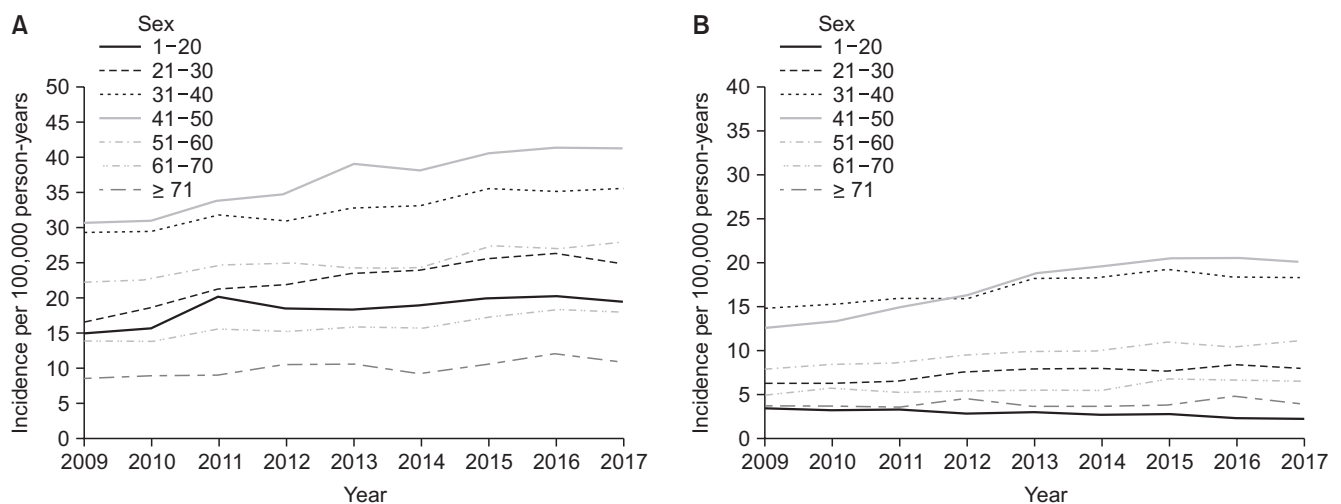


Fig. 2. (A) Trend in incidence of Achilles tendon rupture (per 100,000 person-years) by age. (B) Trend in incidence of surgical treatment of Achilles tendon rupture (per 100,000 person-years) by age.

South Korea. Age of the patients in a year was subdivided into < 20 years, 21 to 30 years, 31 to 40 years, 41 to 50

years, 51 to 60 years, 61 to 70 years, and > 70 years. Seasonal variation was compared using unweighted numbers

of Achilles tendon rupture and surgically treated cases. Seasons were subdivided into four groups based on the generally used meteorological definitions: spring (March to May), summer (June to August), autumn (September to November), and winter (December to February). Income of an individual was divided into five levels of 20% from the lowest in the first quintile to the highest in the fifth quintile. For the economic costs of Achilles tendon rupture, the NHISS shares the figures of total medical costs, composed of insured and non-insured amounts per patient. We could analyze the annual economic condition by categorizing patients into three groups: nonsurgically repaired, surgically repaired, and both. We considered the currency in Korean Won (KRW), where 1,000 KRW equals 0.91 US dollars or 0.77 Euro, according to the Korean Statistical Information Service (KOSIS) exchange rate in 2017.⁸⁾ The incidence and surgical rate change of each year, adjusted by sex, age, and income level, were analyzed by Poisson regression using quasi-Poisson distribution for dispersion parameter with person-years as the offset variable. Models included year as a linear change and sex, age, and the income level as categorical variables. For all models except year-only models, year and one of each categorical variable were included: one model without interaction effects and another with interaction effects between the annual increasing trend and each categorical variable. The overall interaction effects on the annual increasing trend and categorical variable were tested by likelihood ratio test between two models without and with interaction effects. All tests were performed using R 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Sex-Specific

Between 2009 and 2017, a total of 112,350 patients had Achilles tendon rupture, and 44,248 patients underwent surgical treatment. The overall incidence of Achilles tendon rupture demonstrated a thoroughly increasing trend. It was 20.75 in 2009 and 26.53 per 100,000 person-years in 2017, which signified an increase of 28% ($p < 0.001$). The male-specific incidence increased, which was 29.23 in 2009 and 37.76 per 100,000 person-years in 2017. The female-specific incidence increased from 12.25 in 2009 to 15.33 per 100,000 person-years in 2017. The male-to-female relative risk was steady in the study period, which was 2.38 in 2009 and 2.46 in 2017. The interaction effect on annual increase was not observed within subgroups ($p = 0.779$) (Table 1, Fig. 1A).

The overall incidence of surgical treatment also demonstrated an increasing trend. It was 8.10 in 2009 and increased to 10.38 per 100,000 person-years in 2017, which was an increase of 28% ($p < 0.001$). There was a significant interaction effect whereby trends differed between male and female groups ($p = 0.003$). The male-specific incidence of surgical treatment increased from 11.97 in 2009 to 16.66 per 100,000 person-years in 2017. However, the female-specific incidence of surgical treatment slightly decreased from 4.21 in 2009 to 4.12 per 100,000 person-years in 2017. Unlike the steady trend of male-to-female incidence ratio of Achilles tendon rupture, the relative risk of surgical treatment increased from 2.84 in 2009 to 4.04 in 2017 (Table 2, Fig. 1B).

Table 4. Incidence of Surgical Treatment of Achilles Tendon Rupture (per 100,000 Person-Years) by Age

Age (yr)	2009	2010	2011	2012	2013	2014	2015	2016	2017	Annual increase	p-value
Total	8.10	8.37	8.79	9.29	10.13	10.22	10.74	10.57	10.38	1.039	< 0.001*
Age group											< 0.001 [†]
1–20	3.49	3.23	3.26	2.85	2.99	2.75	2.80	2.36	2.25	0.952	
21–30	6.30	6.32	6.61	7.62	8.00	8.04	7.72	8.46	7.96	1.036	
31–40	14.82	15.24	15.93	15.95	18.13	18.33	19.19	18.33	18.33	1.032	
41–50	12.60	13.26	14.98	16.30	18.78	19.54	20.51	20.55	20.06	1.066	
51–60	7.90	8.43	8.65	9.57	9.93	9.98	10.99	10.46	11.24	1.043	
61–70	4.94	5.70	5.24	5.43	5.52	5.52	6.80	6.62	6.49	1.036	
≥ 71	3.67	3.73	3.52	4.56	3.66	3.67	3.86	4.85	3.95	1.018	

*The p-value of annual increasing trend in a model without an interaction effect. [†]The p-value of interaction effects between annual increasing trend and subgroups.

Age-Specific

The age-specific incidence of Achilles tendon rupture showed an increasing trend in all age groups ($p < 0.001$). Patients in the age group of 41 to 50 years maintained the highest incidence throughout the study period. The incidence increased in this age group by 34%, from 30.65 in 2009 to 41.29 per 100,000 person-years in 2017. The lowest rise was among patients in the age group of > 70 years by 26%, from 8.56 in 2009 to 10.86 per 100,000 person-years in 2017. The interaction effect was not reported within subgroups ($p = 0.064$) (Table 3, Fig. 2A).

The age-specific incidence of surgical treatment showed an increasing trend in all age groups ($p < 0.001$), except among patients < 20 years. The significant interaction effect was seen within subgroups ($p < 0.001$). The most notable increase was among patients in the age group of 41 to 50 years by 59%, from 12.60 in 2009 to 20.06 per 100,000 person-years in 2017. Patients in the age group

of < 20 years showed a decrease in the rate of surgical treatment by 55%, from 3.49 in 2009 to 2.25 per 100,000 person-years in 2017 (Table 4, Fig. 2B).

Income Level

The trend of incidence of Achilles tendon rupture and surgical treatment based on income level was reported as quintiles. The first quintile group represented the lowest 20%, and the fifth quintile group represented the highest 20% income in the population. The incidence of Achilles tendon rupture showed an increasing trend in all five groups ($p < 0.001$). Increased incidence of Achilles tendon rupture was observed among patients with higher income levels. The fifth quintile group showed the highest incidence of Achilles tendon rupture of 25.54 in 2009 and 30.99 per 100,000 person-years in 2017. The most evident increase was observed among patients in the first quintile group, with a 39% increase from 2009 to 2017 (Table 5,

Table 5. Incidence of Achilles Tendon Rupture (per 100,000 Person-Years) by Income

Group	2009	2010	2011	2012	2013	2014	2015	2016	2017	Annual increase	p -value
Total	20.75	21.39	24.04	23.83	24.95	24.82	26.63	26.93	26.53	1.032	$< 0.001^*$
Income group											0.521 [†]
5th	25.54	25.90	28.14	28.42	30.13	28.97	31.70	31.31	30.99	1.026	
4th	22.50	21.73	24.85	25.05	26.07	25.97	27.88	28.51	27.94	1.033	
3rd	18.75	18.29	22.33	21.90	22.32	22.36	24.82	24.34	24.46	1.036	
2nd	17.81	17.07	20.10	19.66	19.97	20.99	21.10	23.82	22.10	1.034	
1st	15.54	16.77	19.73	19.32	20.35	21.56	22.67	21.69	21.66	1.040	

Income level has been divided into five levels of 20%. The 5th quintile group is the highest and the 1st quintile is the lowest income group. *The p -value of annual increasing trend in a model without an interaction effect. [†]The p -value of interaction effects between annual increasing trend and subgroups.

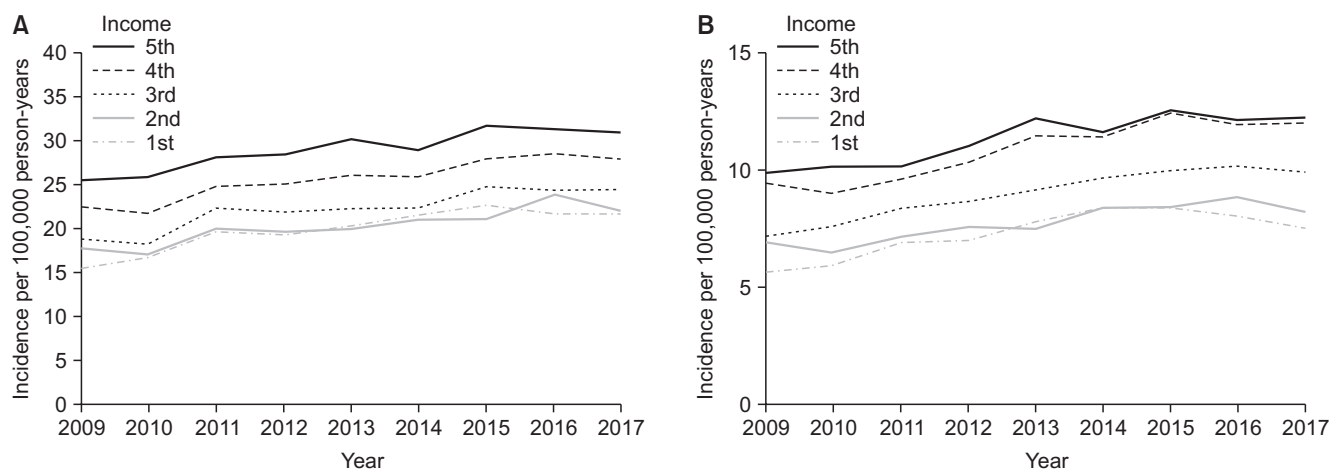


Fig. 3. (A) Trend in incidence of Achilles tendon rupture (per 100,000 person-years) by income. (B) Trend in incidence of surgical treatment of Achilles tendon rupture (per 100,000 person-years) by income.

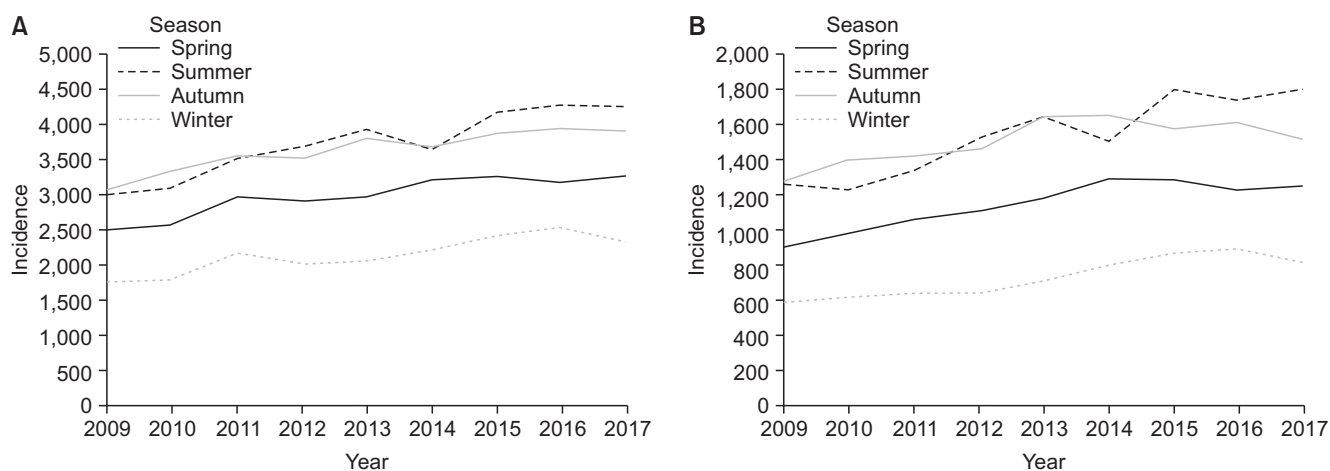
Table 6. Incidence of Surgical Treatment of Achilles Tendon Rupture (per 100,000 Person-Years) by Income

Group	2009	2010	2011	2012	2013	2014	2015	2016	2017	Annual increase	p-value
Total	8.10	8.37	8.79	9.29	10.13	10.22	10.74	10.57	10.38	1.037	< 0.001*
Income group											0.591 [†]
5th	9.88	10.15	10.15	11.01	12.20	11.61	12.53	12.12	12.23	1.031	
4th	9.44	9.02	9.59	10.34	11.48	11.42	12.43	11.96	12.00	1.041	
3rd	7.19	7.60	8.37	8.66	9.15	9.68	9.98	10.17	9.91	1.044	
2nd	6.94	6.48	7.16	7.57	7.49	8.39	8.42	8.85	8.22	1.034	
1st	5.65	5.94	6.92	6.97	7.8	8.42	8.38	8.02	7.55	1.042	

Income level has been divided into five levels of 20%. The 5th quintile group is the highest and the 1st quintile is the lowest income group. *The *p*-value of annual increasing trend in a model without an interaction effect. [†]The *p*-value of interaction effects between annual increasing trend and subgroups.

Table 7. Incidence of Achilles Tendon Rupture by Season

Season	2009	2010	2011	2012	2013	2014	2015	2016	2017
Spring	2,995	3,098	3,514	3,682	3,928	3,629	4,168	4,281	4,245
Summer	3,073	3,341	3,538	3,518	3,805	3,684	3,876	3,940	3,895
Autumn	2,501	2,567	2,971	2,912	2,971	3,211	3,260	3,170	3,268
Winter	1,760	1,798	2,173	2,028	2,054	2,215	2,419	2,533	2,329

**Fig. 4.** (A) Trend in incidence of Achilles tendon rupture by season. (B) Trend in incidence of surgical treatment of Achilles tendon rupture by season.**Table 8.** Incidence of Surgical Treatment of Achilles Tendon Rupture by Season

Season	2009	2010	2011	2012	2013	2014	2015	2016	2017
Spring	1,261	1,228	1,339	1,524	1,643	1,503	1,802	1,735	1,803
Summer	1,277	1,401	1,423	1,459	1,644	1,651	1,576	1,611	1,512
Autumn	905	977	1,060	1,107	1,180	1,291	1,285	1,227	1,248
Winter	587	620	639	642	712	800	869	893	814

Fig. 3A). The incidence of surgical treatment also demonstrated an increasing trend among patients in all five quintile groups ($p < 0.001$). The incidence of surgical treatment was also highest among patients in the fifth quintile group (9.88 in 2009 and 12.23 per 100,000 person-years in 2017). However, those in the third quintile group showed the highest increase by 37% from 2009 to 2017. There was no significant interaction effect for the incidence or surgical rate within any subgroups ($p = 0.521$ and $p = 0.591$, respectively) (Table 6, Fig. 3B).

Seasonal Variation

The increasing trend of incidence of Achilles tendon rupture and surgical treatment was investigated in all seasons. A higher incidence of Achilles tendon rupture was observed in spring and summer. In spring, 2,995 cases of the injury were reported in 2009, which increased to 4,245 cases in 2017. Likewise, in summer, 3,073 cases were reported in 2009, which increased to 3,895 cases in 2017. The least number of cases were reported during winter. However, the incidence showed an increasing trend with 1,760 cases in 2009 and 2,329 cases in 2017 (Table 7, Fig. 4A). The incidence of surgical treatment was also higher in spring and summer. In spring, 1,261 patients underwent surgery in 2009, which increased to 1,803 patients in 2017. The lowest numbers of operations were reported during winter; nonetheless, 587 patients underwent the treatment in 2009, which increased to 814 patients in 2017 (Table 8, Fig. 4B).

DISCUSSION

An increasing overall incidence of Achilles tendon rupture was observed in our study, consistent with previous epidemiologic studies. Moller et al.,⁹ Houshian et al.,¹⁰ Nyysönen et al.,⁶ Lantto et al.,⁴ and Ganestam et al.² reported an increasing trend in European countries including Denmark, Sweden, and Finland since 1987. In North America, increasing trends were reported by Suchak et al.,¹¹ Raikin et al.,¹² Ho et al.,¹³ and Lemme et al.⁵ since 1998. These studies demonstrated male dominance in the incidence rate, which was also evident in our study. The most important finding of our study was that the highest incidence of Achilles tendon rupture was observed among patients in the age group of 41 to 50 years throughout the study period. Patients between 41 and 50 years of age showed the highest increase among all age groups. Nyysönen et al.⁶ conducted a study from 1987 to 1999 and reported that the peak incidence of Achilles tendon rupture was in patients between 30 and 45 years of age. The

study also reported that the incidence increased rapidly among those aged over 40 years. Similarly, Ganestam et al.² conducted a study from 1994 to 2013 and reported that the peak incidence of Achilles tendon rupture was observed among patients in the age group of 31 to 50 years. Furthermore, they observed the most evident increase in patients older than 50 years of age. Huttunen et al.,³ who conducted a study from 2001 to 2012, also showed that the highest incidence was among patients aged 40 to 59 years, and the most evident increase was among those aged > 60 years. The most recent study conducted from 2012 to 2016 by Lemme et al.⁵ reported that although patients between 20 and 39 years of age showed the greatest number of ruptures, the predominantly increasing trend was observed among those between 40 and 59 years of age. These results are consistent with our study, where the peak age of incidence is increasing. In fact, earlier studies have reported a peak incidence of the injury in the younger age group; however, more recent studies have shown higher rates in the older age group, which may reflect an increasing peak age of incidence. The possible explanation for this growing incidence in patients between 41 and 50 years of age could be an interaction between three factors, namely structural and functional changes and an increase in sporting activities. Tuite et al.¹⁴ reported structural changes in human tendons, wherein the diameter of collagen fibers increased, tensile strength decreased, and the tendons became tougher with age. A decrease in the number of fibroblasts with an increase in the extracellular matrix results in a decline in the structure and function of tendons. Functionally, Hess¹⁵ reported that muscle imbalance, decrease in flexibility, and overweight worsen with aging, which could increase the risk of rupture. Indifferently from structural and functional aging, with increasing average life expectancy, the demand for physical activity and interest in recreational sports are increasing among older individuals. In fact, the importance of participating in active leisure and recreational sports has been emphasized for achieving successful aging, as described by Kim et al.¹⁶ This social consent has encouraged the older population to participate more in sports. The increasing demand for sports while structurally and functionally getting older made the older age group most vulnerable to injuries. This is closely related to the concept of overuse as described by Jarvinen et al.¹⁷ Tendons are more susceptible to tendinopathy or tendinosis with a loss of healing potential during aging, which could indicate degenerative changes. At this stage, additional stress could result in increased susceptibility to injuries. Yasui et al.¹⁸ further explained that older patients with Achilles tendinopathy were most susceptible to rup-

ture. Based on the results of our study, the highest increasing trend of incidence, as observed in patients between 41 and 50 years of age from 2009 to 2017, may continue in the future. However, with increasing life expectancy, the peak age might also change, such that in the future, patients between 51 and 60 years of age may represent the group with highest incidence of such injuries. Recently, although the incidence showed a significantly increasing trend from 2009 to 2017, slight declination was observed from 2016 to 2017. This needs to be further investigated in the future to elucidate whether it was the starting point of declining trends or a dip from the current increasing trends.

An overall increasing trend was observed in the incidence of surgical treatment in our study. Surgical treatment has been preferred to nonsurgical treatments in the past because of lower rerupture rates¹⁹⁾ and greater strength after repair.^{20,21)} Surgery was preferred despite risks of complications such as deep vein thrombosis, wound infection, necrosis of the skin and tendon, tendon elongation, and decreased ankle mobility following surgery.^{22,23)}

Despite the overall increasing trend from 2009, the trend decreased from 2015 to 2017. In Sweden³⁾ and Denmark²⁾, decreasing trends have been observed since 2009. These declining trends may be explained by successful outcomes of nonsurgical treatment in recent studies, which have shown similar or better rerupture rates^{17,24,25)} and good strength following nonsurgical treatment,²³⁾ while avoiding the risk of complications of surgical treatment. In our study, further investigations may be required to decide whether the recent decline of incidence of surgical treatment from 2015 was actual late starting of decline of trends or a dip from increasing trend. However, there are few possible explanations for both scenarios. First, the superior effectiveness of nonsurgical treatment over surgical treatment may require more evidence for acceptance by physicians in our study. In a recent meta-analysis by Ochen²⁶⁾ including both observational and randomized clinical trials, lower rerupture rates shown in surgical treatment still remain controversial. Second, as Soroceanu et al.²⁴⁾ and Kim and Yoon²⁷⁾ reported, successful outcome from nonsurgical treatment can be expected when followed by an early range of motion and adequate functional rehabilitation. The concept of an early range of motion does not have consensus in terms of “when to start,” “how to perform,” or “to what degree,” resulting in difficulty for physicians. Finally, the facilities or human resources for rehabilitation in South Korea are generally inadequate to increase patient compliance. KOSIS⁸⁾ has investigated patients admitted to the orthopedic department for an

average of 11.8 days. And according to a previous study of outpatient consultation time based on a single general hospital in Korea, orthopedic specialists spent an average duration of only 4 minutes on consultation.²⁸⁾ Although this is limited and an indirect assumption to evaluate the condition of postoperative management and rehabilitation, it may prove difficulties.

As for the income level, the higher income quintile groups experienced more Achilles tendon rupture than lower quintile groups. The possible explanation to our result is that higher income groups may have more suitable condition to participate in physical activities than lower income groups, which causes more changes of injury. In fact, Kim and So²⁹⁾ reported that the higher income group positively correlated with active participation in physical activities. As mentioned earlier, considering that Achilles tendon rupture occurs mostly during physical activities, particularly in high-energy sports,^{2,4,5)} the higher income quintile groups may have participated more in physical activities as shown in our results, in which most Achilles tendon ruptures occurred in the higher income quintile groups.

Regarding seasonal variation, various studies from different countries have reported a higher incidence of the injury in specific seasons, such as spring and summer in Canada¹¹⁾ and fall in Denmark.²⁾ However, the difference was not statistically significant. According to the study by Ganestam et al.,²⁾ which is the first nationwide study to our knowledge, there was no statistically significant difference in the incidence between seasons. In our study, roughly similar incidences of the injury were observed in spring, summer, and autumn; however, the incidence was lower in winter. Results of previous studies and ours do not indicate any clear correlation based on seasonal variations. Instead, Achilles tendon rupture was found to be more dependent on its distinct characteristics, caused by high-energy sports such as badminton, soccer, and basketball. Thus, the comparably low incidence in winter could be attributed to the reduced activity levels during the season.

Despite our efforts to reduce bias, there were some limitations in our study. First, since diagnostic code S86.0 includes all types of injuries, no distinguishment or elimination within types such as laceration or rupture, acute or degenerative, and non-sports-related or sports-related were possible. Second, misdiagnosis may have affected our results. There is a possibility that physicians may have misdiagnosed injuries with similar features, such as ankle pain, ankle sprain, Achilles tendinitis, or Achilles tendinopathy as Achilles tendon rupture or vice versa. Once misdiagnosed, there is no way to correct this in the review

process. Third, rerupture or collateral ligament injury in the same patient could be counted as multiple cases. Thus, all these three reasons could have led to an overestimation or underestimation of both the incidence and the surgical rates in our results.

In conclusion, the incidence of Achilles tendon rupture and surgical treatment demonstrated an increasing trend. In terms of age, patients between 41 and 50 years showed the most rapid increment in the incidence compared to those in other age groups. This may be explained by their increasing demands pertaining to physical activity with concomitant structural and functional decline of the Achilles tendon. The lowest incidence of Achilles tendon rupture was observed during the winter season, and patients in the higher income quintile groups experienced more injuries than those in the lower income groups. To

the best of our knowledge, this is the first study that investigated the epidemiology of Achilles tendon rupture in South Korea, specifically in Asia, using the actual numbers obtained from the entire population.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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