Ankle fractures in Finland: 118,929 operatively treated between 1987 and 2019

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Background and purpose — Ankle fractures are one of the most common fractures requiring operative treatment. They occur most commonly in postmenopausal women and younger men and recent studies suggest that the incidence of ankle fractures is increasing. In this registry study, we analyze inpatient data of operatively treated ankle fractures during a period of 33 years from our comprehensive nationwide register data.

Patients and methods — The data on operatively treated ankle fracture patients between January 1, 1987 and December 31, 2019 was collected from the Finnish National Hospital Discharge Register and analyzed.

Results — 118,929 ankle fractures were treated operatively. These included lateral malleolar fractures (33%), bi- or trimalleolar fractures (51%), medial malleolar fractures (7%), and other fractures (9%). Mean age was 53 (SD 17) years for women and 43 (16) for men. The average annual incidence rate was 69 per 100,000 person-years. Over the past 3 decades incidence has leveled off for women and has started to decline for men. However, the incidence is increasing in the elderly women group (over 70 years of age). In the over 50 age group, comorbidities have increased over the years, being more common in men than in women. The incidence of ankle fractures was higher during the winter months (November–March).

Interpretation — The number of operatively treated ankle fractures has leveled off during the last 33 years. However, nowadays we operate on more difficult fractures in elderly patients with comorbidities.

Ankle fractures are one of the most common fractures requiring operative treatment. The incidence of ankle fractures is estimated at 179–187 per 100,000 person-years (**1,2**). In the UK data, ankle fractures are the third most common hospital-requiring fracture after hip and wrist fractures (**3**).

Ankle fractures are most common in postmenopausal women and younger men, and the annual incidence increases in wintertime (**2**). In a large Swedish registry study (1987–2004), the incidence of ankle fractures treated in hospital was 71 per 100,000 person-years, and 83% of fractures required operative treatment (**4**). In previous studies, the incidence of ankle fractures increased (**5,6**), which was considered to be due to an aging population and increased recreational activities (**7**).

We assume that, as the population ages, the proportion of older people with more comorbidities and more difficult fractures will increase. In addition, according to current knowledge, some of the ankle fractures that have been treated operatively before can now be treated nonoperatively (**8-10**), thus the number of surgeries could be expected to be declining.

We analyzed the incidence, annual trend, age and sex distribution, associated comorbidity, and seasonal variation of operatively treated ankle fractures in Finland between 1987 and 2019.

Patients and methods

This register study was performed on the whole population of Finland (5,525,292 inhabitants on the last day of 2019) from 1987 to 2019.

We identified all ankle fracture patients who were treated operatively in Finnish hospitals between January 1, 1987 and December 31, 2019 from the Finnish National Hospital Discharge Register (known as the Care Register for Health Care

since 1994), which is maintained by the Finnish Institute for Health and Welfare. It provides data on age, sex, domicile of the subject, duration of hospital stays, primary and secondary diagnosis, and surgical procedures performed during the hospital stay. The register contains data on procedures performed in public and private hospitals, and the quality of the data is good ([11]). We gathered age- and sex-group specific population sizes from Statistics of Finland's (StatFin) online services, which is maintained by Statistics Finland. In particular, we used the annual mean population information according to age and sex while calculating annual incidences.

The identification of operatively treated ankle fractures was based on the combination of diagnosis and operation codes. We used fracture codes that referred to ankle fractures (fractures of the distal tibia, distal fibula, or both) and operation codes, which included ankle fracture open or closed reduction, and internal fixation or external fixation (for example, Hoffman external fixation).

For the years 1987–1996, we used the ICD 9 codes 8240A–8249A, and the hospital union procedure nomenclature codes 9128 (open reduction and internal fixation), 9126 (closed reduction and internal fixation), and 9130 (external fixation). For the years 1996–2019, we used ICD10 codes S82.3–S82.9 and NOMESCO procedure codes NHJ10 (internal fixation of fracture of ankle), NHJ12 (internal fixation of fracture of ankle using bioimplant), and NGJ70 (external fixation of fracture of lower leg). We divided the ankle fractures (operated on with specific procedure codes) into 4 classes: Medial malleolar fractures consist of ICD-9 codes 8240A-8241A and ICD-10 code S82.5. Fractures of the lateral malleoli consist of ICD-9 codes 8242A–8243A and ICD 10 code S82.6. Bi- and trimalleolar fractures consist of ICD-9 codes 8244A–8247A and ICD-10 codes S82.7-S82.8 and other ankle fractures ICD 9 8248X–S249X and ICD10 codes S82.3, S82.4, and S82.9.

We stratified register-based numbers of operations by year, age group (0–19, 20–49, 50–69, and over 70 years), sex, and season (summer/winter). We calculated the incidence of operatively treated ankle fractures per 100,000 person-years in total, for genders and by age groups. To illustrate the continuous smoothed trend from stratified values, we used the locally estimated scatterplot smoothing (LOESS) technique.

We examined patients' comorbidities according to the CCI, which was designed to predict 1-year mortality on the basis of a weighted composite score ([12]). It has been adapted and validated to work also with Finnish register data ([13]).

Statistics

The Poisson regression model was used to obtain incidence rate ratios (IRR) of the considered risk factors (age group, sex, season (summer/winter), calendar year). The numbers of fractures as well as the follow-up times in person years (approximated by corresponding population figures in Finland) were tabulated according to the used stratification. A logarithm of

the follow-up time was included as an offset to the model, as we modeled the incidence and not counts. Because the length of the winter and summer months were not equal, the follow-up time in each year for every age, season, and sex group was weighted according to the number of winter and summer months before the analysis. Year was used only for adjustments, and was modeled by using natural splines to account for a potentially non-linear effect. To mitigate the effect of over-dispersion, we used White's sandwich estimator to obtain the robust standard errors and calculated the p-values together with the 95% confidence intervals accordingly.

We used the residual deviance (chi-square test) to evaluate our model and ended up using robust standard errors to compensate for overdispersion and natural splines for modelling calendar year. In any case, we used Poisson regression to calculate IRRs for a limited number of covariates, i.e., it was more a technical tool for adjusted IRR calculations than a real statistical model. The seasonal average number of operatively treated ankle fractures is presented with the 95% confidence interval (CI).

Ethics, funding, and potential conflicts of interest

Results

Between 1987 and 2019, 118,929 ankle fractures were operatively treated in Finland. Of these, lateral malleolar fractures numbered 33%, bi- or trimalleolar fractures 51%, there were 7% medial malleolar fractures, and other fractures numbered 10,159 (9%). For both sexes, the annual incidence increased towards the turn of the 21st century, after which the incidence in women leveled off and in men began to decline (Figure 1).

The peak incidence in women was 122 per 100,000 person-years in the 50–69 years age group and in men 92 per 100,000 person-years in the 20–49 years age group. The incidence of bi- or trimalleolar ankle fractures in women over 70 years of age has increased from 27 to 61 per 100,000 in three decades, with a more moderate increase in men, from 17 to 26 per 100,000. In contrast, the incidence of bi- or trimalleolar ankle fractures in 50–69-year-olds has remained stable in both women and men. The incidence decreased most in men aged 20–49 years (Table 1, Figure 2).

The seasonal variation is shown in Figure 3. The largest daily peaks are in the winter months (November–March). An average of 241 (95% Cl 212–273) ankle fractures were
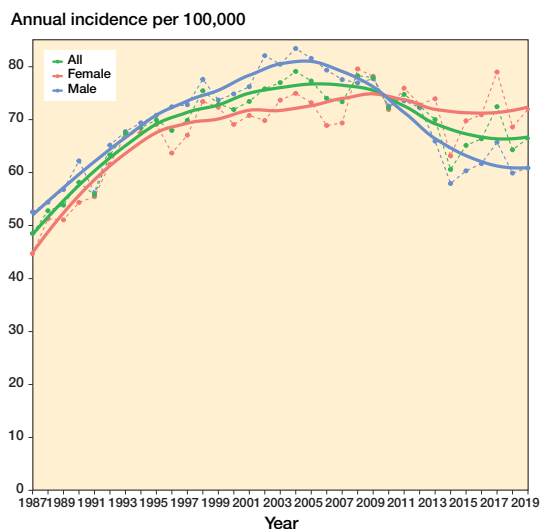
Figure 1. Ankle fractures incidence per 100,000 between 1987 and 2019. Solid lines illustrate the LOESS curves through data points with 50% smoothing span.

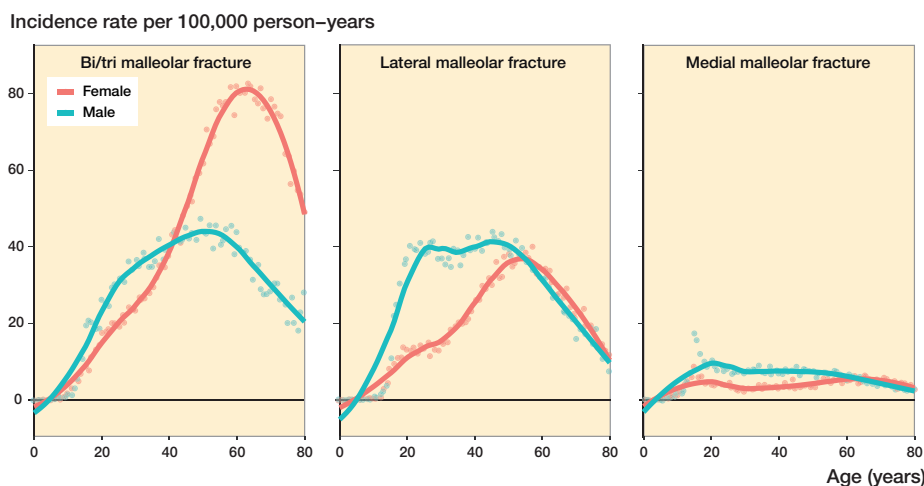**Incidence rate per 100,000 person–years**

Figure 2. Incidence rates per 100,000 person-years of different ankle fractures during 1987–2019 for both genders plotted against age. Note that only persons of age 80 or under are shown in the plot. Solid lines illustrate the LOESS curves through data points with 50% smoothing span.

Table 1. Age and sex demographics of different fracture types. Values are count (%) unless otherwise specified

	Bi-/tri malleolar fracture	Lateral malleolar fracture	Medial malleolar fracture	Other fracture	p-value
Total	60,174 (51)	40,130 (34)	8,466 (7)	10,159 (9)	
Mean age (SD)	51.0 (17)	45.2 (16)	41.7 (19)	44.9 (19)	< 0.001
Age group					
0–19	2,119 (4)	2,097 (5)	1,417 (17)	1,284 (13)	< 0.001
20–49	24,879 (41)	21,643 (54)	3,966 (47)	4,469 (44)	
50–69	24,256 (40)	13,627 (34)	2,348 (28)	3,451 (34)	
> 70	8,920 (15)	2,763 (7)	735 (9)	955 (9)	
Sex					
Male	24,336 (40)	23,248 (58)	5,149 (61)	5,999 (59)	< 0.001
Female	35,838 (60)	16,882 (42)	3,317 (39)	4,160 (41)	

operatively treated in the summer months and 383 (95% Cl 346–423) in the winter months.

Chronic diseases such as diabetes, chronic lung disease, and malignancies emerge as underlying diseases. Comorbidities increase with age. In the elderly group, comorbidities are more common in men than in women. In the 50–69 and over 70 age groups, comorbidities have increased over the years (Figure 4, Table 2, see Supplementary data).

Based on the estimated coefficients of the Poisson regression model, the incidence rate ratio (IRR) for men is 2% higher compared with women, and people aged 50–69 have a twofold risk compared with those aged 20–49 years (Table 3). The IRR is 62% higher in the winter months. We decided to leave children out of this Poisson regression analysis because their fractures and treatment are different. However, differences in the incidences in all age groups can be viewed in Figure 6 (see. Supplementary data).

Discussion

Our study of all operatively treated ankle fractures in Finland over a period of 33 years shows that the incidence of operatively treated ankle fractures is leveling off in women, and in men has started to decline.

In women, more severe, bi- and tri-malleolar fractures are more common, and the mean age is higher. In both sexes, the incidence is decreasing in the age group 20–49 years, steady in 50–60-year-olds, and in > 70 years is for men steady and for women increasing (Figure 5). This would suggest that ankle fractures are increasingly associated with fragility and osteoporosis. Similar views were presented by Rammelt in 2017 and Biver et al. in 2015 (**14,15**). It must also be kept in mind that diagnostics and treatment of osteoporosis have evolved significantly during follow-up, and this may also affect the results.

Table 3. Estimated Poisson model coefficients, IRRs, robust 95% confidence interval (rCI), and p-value

Factor	IRR (rCI)	p-value
Male sex (ref. female)	1.02 (1.00–1.04)	0.07
Age group (ref. 20–49)		
50–69	2.02 (1.98–2.06)	< 0.001
> 70	0.76 (0.73–0.80)	< 0.001
Winter season (ref. summer)	1.62 (1.59–1.65)	< 0.001

Adjusted for year modeled with natural splines.
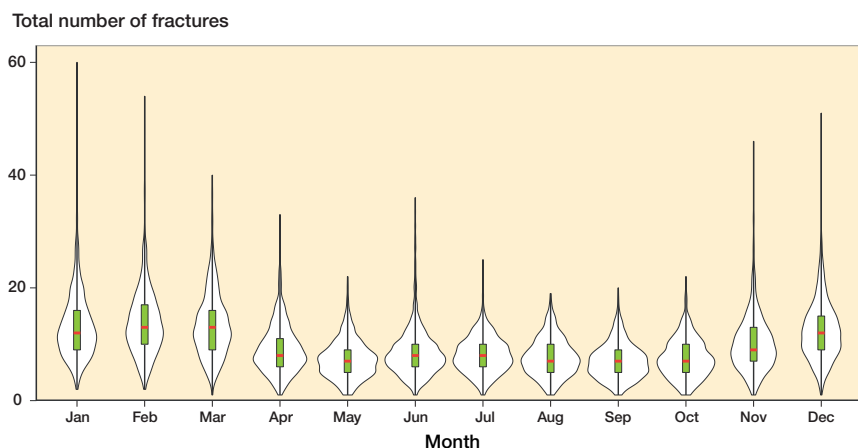
Total number of fractures

Figure 3. Average number of monthly fractures from 1987–2019 for both age and sex groups. The violin plots (outlines around the boxplots, which show the median and IQR) illustrate the estimated kernel probability density estimates of the monthly fractures; the wider the violin plot is the more observations have accumulated around that particular number of fractures.
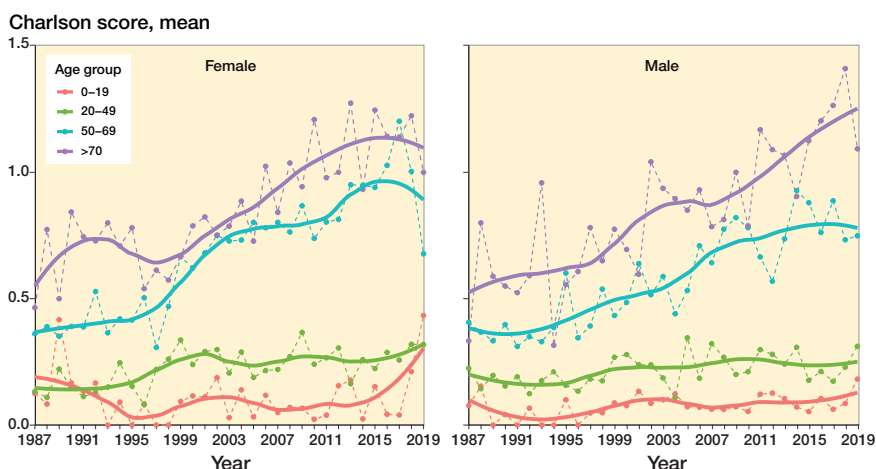
Charlson score, mean

Figure 4. Average Charlson score from year 1987 to 2019 in each age group for females and males. Solid lines illustrate the LOESS curves through data points with 30% smoothing span.
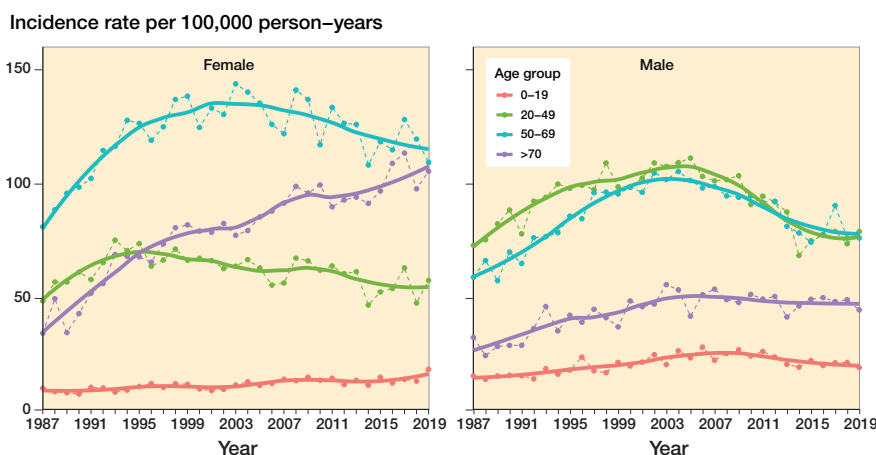
Incidence rate per 100,000 person–years

Figure 5. Ankle fracture incidence per 100,000 between 1987 and 2019 in each age group for females and males. Solid lines illustrate the LOESS curves through data points with 50% smoothing span.

The mean age in men is lower than in women, agreeing with previous studies (**4**). A new and interesting finding of our study is the clear decline in the incidence in men in the 20–49 age group, which could be explained by the more nonoperative treatment practice (**8,16,17**). Furthermore, no polyclinic or outpatient clinic ankle fracture operations were performed in Finland during the follow-up period and most of the private sector ankle fracture operations are included in the register.

It is known that comorbidity increases with age and during the follow-up period Finland's population has increased by 11% and the proportion of the elderly (> 65 years) is also larger than before. In that sense, it is expected that comorbidities have increased over the years, especially in the elderly, but the change can also be seen in the age group 50–69 years. The explanation for the change may be that we now operate on sicker patients than before because it is safer with more advanced surgical techniques. Another explanation is that we are becoming better at diagnosing and registering comorbidities; the coverage of registers has also been improved. Although surgical techniques have evolved over the years, it remains to be seen whether the number of complications will increase.

In 2012, Thur et al. (**4**) published an epidemiological study of ankle fractures in Sweden from 1987–2004. In their study, the incidence of ankle fractures beginning to level off in the 21st century and the annual increase was low (0.2%). In Swedish data, 83% of ankle fractures treated in hospital were operated on. The mean age of women was 58 years, with the most typical being a bi-/trimalleolar fracture (57%). The mean age of men was 45 years, and the most typical fracture was of the lateral malleoli (49%). The demographic and weather conditions in our neighboring country are similar, so the study can be considered comparable. In our study the average age of Finnish women was 53 years, which is lower than in their study, and the most common type of fracture was bi- or trimalleolar (59%), as in Swedes. In men, the mean age was 43 years, which is lower than in Sweden, and the most common type of fracture is a bi- or trimalleolar fracture (41%), although lateral

malleoli fractures account for 40% of fractures. Our study included only operatively treated ankle fractures, and this can explain differences in percentages of lateral fractures in men and younger ages in both sexes.

In 2016, Kannus et al. (18) reported that ankle fractures related to low-energy falls in the elderly (> 60 years) increased sharply between 1970 and 1997, after which the incidence of hospitalized ankle fractures decreased steadily until 2014. Our study includes more recent data up to 2019 and includes all age groups as well as more detailed information on fracture patients.

In 2018, Juto et al. (2) in a study from northern Sweden on the epidemiology of adult ankle fractures found that they were often caused by low-energy injury, and were more common in women. Annually, incidence increased when the mean temperature was close to 0 degrees Celsius and with roads and sidewalks at their most slippery. In our study, similar changes can be seen with the incidence increasing during November–March. During these months, in Finland average temperatures are 0 degrees Celsius or below and the majority of slip accidents occur. In addition, their study considers whether an ankle fracture can be classified as osteoporotic or not. A higher frequency in women, caused by low energy of injury, and an increase in incidence with age would suggest the signs of osteoporotic fracture (2). In previous studies, ankle fractures were not associated with osteoporosis (19,20). However, in 2015, Biver et al. (15) showed an association between lower bone mineral density and ankle fracture. Our study supports the idea that an ankle fracture is becoming a fragility fracture in older people with poorer bone density.

Partio et al. (21) in a study (1996–2016) found that operatively treated ankle fractures are most common in young men and elderly women. The total incidence of operatively treated ankle fractures has decreased. This is, of course, one conclusion but on closer inspection total numbers appear to be leveling off in women and declining more clearly in men. In their study, one explanation for the reduction in operative treatment of ankle fractures was considered to be a more nonoperative treatment practice; stable ankle fractures can be treated nonoperatively. According to current knowledge, more than half of Weber B fractures are stable and can be treated nonoperatively with a few weeks of plaster or orthosis (8,17,22). According to our study, the total number of operatively treated ankle fractures would appear to have started to decline in the early 2000s. One explanation for this change could be that the primary treatment of ankle fractures has shifted more to primary healthcare in the 21st century and become more nonoperative in that sense.

To our knowledge, our study is one of the largest on operatively treated ankle fractures. The strength of our study is the long calculation of a time series and the data collected from a high-quality comprehensive national register, which covers the whole of Finland. Furthermore, the coverage and reliability of the Finnish National Hospital Discharge Register data is good (11,23). Another strength of our study is that we also studied patients' comorbidities and looked at seasonal variation. Weaknesses in the study include changes in classifications and registers over time. Despite the changes, the numbers behave consistently and as expected, suggesting that the results are reliable. A weakness in our study is that in ICD-10 classification there is no specific code for bi- and trimalleolar fractures. S82.7 and S82.8 refer mostly to those fractures. ICD-10 codes S82.3 and S82.9 were also included in this study because they were recorded extensively along with the operation code NHJ10 (internal fixation of the ankle fracture), which is primarily the operation code for the ankle fractures NHJ12 (internal fixation of fracture of ankle using bioimplant) and NGJ70 (external fixation of fracture of lower leg). We considered a combination of diagnosis and operation codes to mostly represent ankle fractures, although for example combination S82.3 + NGJ70 may contain some Pilon fractures. In any case, diagnoses in those classes without relevant operation code were excluded. Another weakness is that, in such long-term follow-up, indications for ankle fracture surgery vary based on both standard practice and alternatives.

In summary, although people are aging and have more active lifestyles, operatively treated ankle fracture incidence has remained steady in the 2000s. However, the incidence of ankle fracture in elderly patients is increasing and these patients have more comorbidities, which may lead to more severe fractures and increased risk of complications.

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Supplementary data

Table 2. Sex demographics of Charlson comorbidities, which cover 118,929 incidences in total from year 1987 onward. Values are count (%)

| Comorbidity	Male	Female	Total
Chronic pulmonary disease	876 (15)	1,407 (16)	2,283 (16)
Diabetes with chronic complications	471 (8)	561 (6)	1,032 (7)
Any malignancy (including leukemia and lymphoma)	766 (14)	1,545 (18)	2,311 (16)
Diabetes without chronic complications	982 (17)	1,205 (14)	2,187 (15)
Congestive heart failure	326 (6)	539 (6)	865 (6)
Myocardial infarction	367 (6)	301 (3)	668 (5)
Cerebrovascular	567 (10)	952 (11)	1,519 (11)
Rheumatological disease	163 (3)	783 (9)	946 (7)
Hemiplegia or paraplegia	49 (1)	76 (1)	125 (1)
Peripheral vascular disease	274 (5)	271 (3)	545 (4)
Mild chronic liver disease	331 (6)	271 (3)	602 (4)
Moderate or severe renal disease	144 (3)	178 (2)	322 (2)
Dementia	103 (2)	421 (5)	524 (4)
Peptic ulcer disease	182 (3)	163 (2)	345 (2)
Metastatic solid tumor	25 (0.1)	39 (0.1)	64 (0.1)
Moderate or severe liver disease	54 (1)	30 (0.3)	84 (1)
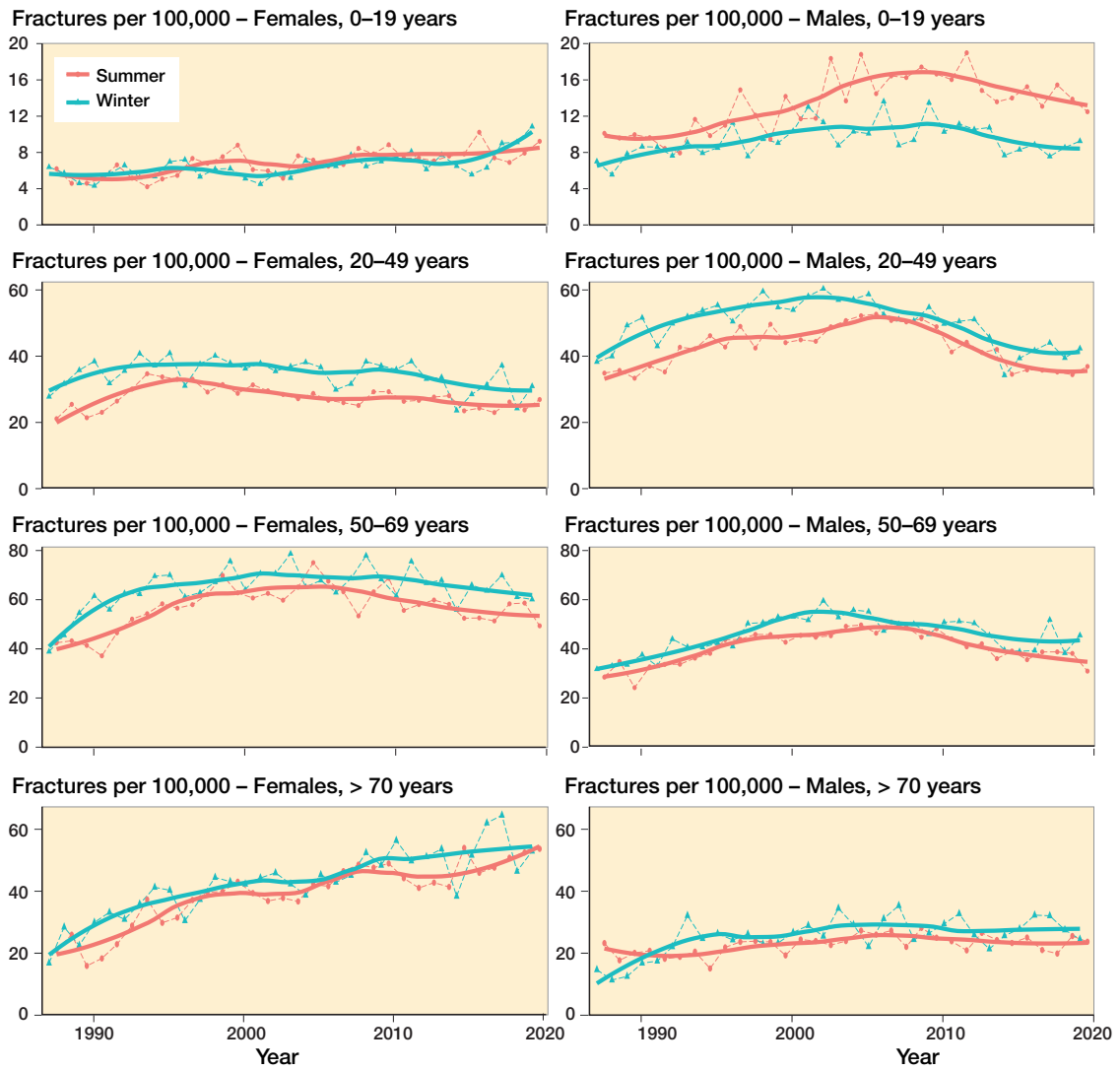
Figure 6. Incidence rate per 100,000 of seasonal fractures from 1987–2019 for both ages and sex groups. The solid lines illustrate the LOESS curves through data points with 50% smoothing span.