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Sports Injury Patterns and Economic Consequences Before and During the COVID-19 Pandemic: A Comprehensive Study of Norwegian Sports From 2017 to 2020 Using Insurance Data

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ABSTRACT

Understanding injury rates and costs is crucial for targeted prevention, yet data across sports remain sparse. Furthermore, information on the impact of the COVID-19 pandemic on injuries across sports is limited. This study aimed to describe injury incidence rates, injured body regions, costs, and mean cost per 1000 athlete year across different sports before and during the COVID-19 pandemic. The study analyzed insurance data from licensed Norwegian athletes aged 13–50 years participating in football, handball, athletics, gymnastics, and swimming over a four-year period (2017–2020). Injury incidence rates, body region, costs, and mean cost per 1000 athlete year, as well as differences in injury rates between sports, sex, age groups, before and during the first year of the COVID-19 pandemic were analyzed. Over the full study period, the highest injury incidence rates were found in athletics, followed by handball, compared to football, gymnastics, and swimming. Lower extremity injuries accounted for the highest incidence rates and costs across sports. Surgical interventions in handball and football accounted for more than half of the costs. Over one fifth of injuries in gymnastics led to permanent medical impairment. During the first year of the COVID-19 pandemic, the number of licensed athletes and incidence rates decreased, except for athletics, which experienced an increase in both. The findings highlight the need for targeted injury prevention measures, particularly in athletics and for lower extremity injuries in handball and football. The fact that one in five injuries in gymnastics resulted in medical impairment is a cause for concern. The impact of the COVID-19 pandemic on sports participation and injury incidence underscores the influence of external factors on sports-related injuries.

1 | Introduction

Participation in sports is popular among many individuals across various age groups. Unfortunately, the downside of sports participation is a high incidence of injuries. The incidence is presented in several studies, such as football [1, 2], handball [3], collegiate sports [4, 5], track and field [6], gymnastics [7] and Olympic events [8, 9]. There is a lack of comprehensive knowledge regarding injuries in various youth and adult sports, especially where identical study methodologies

have been employed. A better overview of the extent and types of injuries can assist sports in general, and sports federations in particular, in targeting measures to reduce injuries in athletics.

Despite the high incidence of sports injuries, their economic impact remains understudied. Linking injury incidence with cost data can enhance understanding of consequences beyond the individual and the sport setting [10]. For example, a study from Flanders using insurance data from 14 sports found that ACL injuries were the costliest and foot injuries the least, with handball showing the highest injury rates and swimming the lowest [11]. Further research and a deeper understanding of the economic consequences of sports injuries and affected groups are essential for informing targeted, cost-effective, and sustainable injury prevention strategies.

The COVID-19 pandemic has influenced people's lives in several ways [12], and young people in particular [13]. Reduced participation in sport has been registered. In Norway, the Norwegian Sport Federation experienced a 9.5% reduction of members during the first year of the Covid pandemic [14]. Regarding injuries, one study has reported a 32% reduction of traumatic injuries in a single-center study from Holland analyzing the effect of the first month of the Covid lockdown [15]. In a study from US emergency visits, they had a 77% reduction of injuries from organized team sports and a 66% reduction from organized individual sports seen during the beginning of the pandemic [16]. While these studies highlight short-term effects on injuries, it remains unclear whether the impact of the pandemic varied across different sports.

In this study, we aimed to describe the injury incidence, injured body regions, direct health costs, and mean costs per 1000 athlete years among male and female insurance licensed athletes in football, handball, athletics (track and field), gymnastics, and swimming over a four-year period. In addition, it examined differences in injury incidence rates across sports, genders, and age groups, as well as changes before and during the first year of the COVID-19 pandemic.

2 | Methods

2.1 | Study Design

This study utilized a cohort design, analyzing insurance data from licensed athletes across five sports: football (soccer), handball, athletics (track and field), gymnastics, and swimming, spanning the years 2017 to 2020. In Norway, it is mandatory for athletes to obtain a license from the respective sports federations, which includes coverage for accidents and injuries occurring during practice, competitions, training camps, and travel related to these activities. The insurance policy covers both sudden and gradual onset injuries. The study was supported by sports federations, which allowed the insurance company to provide all athlete insurance reports to the study group. Injury data were sourced from Norwegian insurance companies Gjensidige and If, anonymized, and exported to a Microsoft Excel file before being sent to the study group. Consequently, injury information could not be traced back to any individual athlete, and informed consent from participants was not required due to the de-identified nature of the data.

This study was carried out according to the Norwegian Agency for Shared Services in Education and Research guidelines. The project was also not covered by the Health Insurance Act. Therefore, there was no obligation to apply to the Regional Ethical Committee, nor was there anything that needed to be addressed in NIH's ethical committee.

2.2 | Population

The study population consisted of licensed athletes aged 13–50 years who participated in five sports. The number of licensed athletes was obtained from the respective sports federations, which play a crucial role in the mandatory licensing process for competitive athletes.

2.3 | Definitions and Data Collection

In accordance with the IOC consensus statement on injury reporting [12], an injury was defined as tissue damage or deviation from normal physical function irrespective of time loss and medical attention. Athletes (or parents for athletes younger than 18 years) reported sudden-onset (resulting from a specific, identifiable event) [12] and gradual onset injuries (without a clear precipitating event) [12] electronically to the insurance company if they were associated with any costs for the athlete using a standardized injury form. Direct health care costs (expenses directly related to diagnosis, treatment, and rehabilitation of an injury) involved costs from the following categories: physiotherapy, physician, manual therapy, chiropractor, surgery, traveling expenses, or medical disability. Medical disability refers to a lasting state of physical and/or mental impairment that significantly hampers functionality. This impairment was assessed independently of one's occupation, potential limitations in generating income, recreational pursuits, or similar factors. Each athlete had a personal contribution for each injury report. If the costs did not exceed this contribution, no payouts were made to the athlete. However, if the costs exceeded the personal contribution, a payout was made to the athlete. Only direct healthcare costs were covered. Indirect costs such as loss of income or productive loss were not covered by the insurance companies [10].

The standardized form included information on the athletes' affiliated sports federation, date and year of injury, age, gender, and the injured body region. Based on this information, injuries were classified into body regions based on the IOC consensus statement [12].

Injury reports with and without payouts to the athletes were included. Injury reports from persons with insurance for

participating in "one single events," typically a one-day event that was organized outside the sports federation, officials and coaches' insurance were excluded. In addition, cases with athletes < 13 years or > 50 years and cases not reporting age were excluded. Athletes younger than 13 years are covered by the Norwegian Sports Federation "children sports insurance", which means that all treatment was without costs and are therefore excluded from this material. Mean costs/athlete-year was defined as the product of the incidence rate expressed as injuries per athlete-year and costs calculated as above.

2.4 | Data Analysis

All statistical analyses were conducted using IBM SPSS Statistics 28.

Injury incidence rates for each sport were calculated by dividing the total number of new injuries reported to the insurance company each year by the total number of licensed athletes in the given year. An athlete-year was defined as the number of athletes licensed per year, summed when incidence was reported across multiple seasons. Changes in athletic years, injury claims, and incidence are reported in percent, comparing the seasons 2017–2019 with 2020.

The Incidence Rate Ratio (IRR) with 95% confidence intervals (CI) was used to compare incidence rates across sexes and sports. A significance level of 0.05 was applied to determine statistical significance.

We used a bottom-up approach to estimate total costs per sporting code by adding the sum of unit costs per injury case per sport to calculate total expenditure.

3 | Results

3.1 | Population

The total number of athletes varied between the different sports, with yearly more than 200 000 athletes participating in football, while swimming and gymnastics had the lowest numbers of participants with around 3500 athletes (Table 1). For all five sports a reduction in number of licensed athletes was found from 2019 to 2020 (when COVID-19 restrictions appaired). The relative reduction of licensed athletes from 2019 to 2020 was for gymnastics: −26%, handball: −21.5%, athletics: −21.5%, swimming: −7.7% and football: −6.2.

3.2 | Injury Reports and Incidence Rates

A total of 45 597 injury reports (cases) were reported to the insurance companies, including injury date during the study period 2017–2020, with 2703 being excluded due to wrong age or no reported age. Hence, this study includes 42 894 injury reports in the five sports during the study period (2017 to 2020). The distribution of the total number of injury reports among the sports was: Athletics $n = 2612$, football $n = 23\,365$, gymnastics $n = 686$, handball $n = 15\,794$, and swimming $n = 437$.

The proportions of injury cases without insurance payouts across various sports were: athletics 47.5%, football 58.9%, handball 69.8%, gymnastics 46.5%, and swimming 51.7%.

The highest overall incidence rates over the full period were observed in athletics (151.7 per 1000 athlete-years) and handball (101.2 per 1000 athlete-years), both in the overall data and when examining yearly incidence figures (Table 4).

The incidence rate and incidence rate ratios between female and male in each sport by body region are displayed in Table 2. In athletics, most injuries occurred in the lower extremities with no sex differences. In both handball and football, the female players had a higher lower extremity injury incidence rate, while the overall injury incidence rate was the same among female/male players in handball. In both football and gymnastics, we found a higher overall injury incidence rate among male athletes. Female athletes in swimming had a higher injury rate than male athletes, especially for head and neck injuries. In gymnastics, male athletes had higher rates for all injured body regions (Table 2).

In the younger age group (13–19 years), female athletes had a slightly higher injury incidence rate than males, except in gymnastics, where males had a higher injury incidence rate. In the 20–25 years age group, the injury risk was much higher in swimming among female athletes (incidence male 17.1 vs. female 29.3 per 1000 athlete years). For the oldest age group, female athletes had a much higher injury risk in athletics, handball, and swimming, while men had a higher risk in football (Table 3). In all sports, the incidence was lower in the age group above 36, except in gymnastics, where the incidence was more than tripled.

3.3 | Body Region, Mean Cost Per 1000 Athlete Year, Payment Categories and Medical Impairment

Football and handball resulted in the largest disbursements from insurance companies, amounting to a total of NOK 90.8

TABLE 1 | Number of athletes through study years 2017–2020 and total athletes per sport.

Sport	2017	2018	2019	2020	Total athletes study period
Athletics	4359	4439	4718	3703	17 219
Football	206 350	204 344	204 125	191 552	806 371
Gymnastics	3347	3495	3648	2701	13 191
Handball	40 360	41 078	41 787	32 821	156 046
Swimming	3797	3684	3961	3655	15 097
All sports	258 213	257 040	258 239	234 432	1 007 924

TABLE 2 | Number of injury reports and percent (%), incidence rate (incidence per 1000 athlete years), and incidence rate ratio (IRR) between female and male in each sport by body region.

	Head/neck	Trunk/back	Upper limb	Lower limb	Other	Unknown	Total
Athletics							
Male incidence, *n* (%)	9 (0.7)	111 (8.3)	69 (5.2)	1031 (77.0)	72 (5.4)	47 (3.5)	1339 (100)
Male incidence rate	1.0	11.9	7.4	110.2	7.7	5.0	143.1
Female incidence, *n* (%)	10 (0.8)	115 (9.0)	61 (4.8)	951 (74.7)	64 (5.0)	72 (5.7)	1273 (100)
Female incidence rate	1.3	14.6	7.8	121.0	8.1	9.2	162.0
Female versus male IRR (95% CI)	1.3 (0.4–2.2)	1.2 (1.0–1.5)	1.0 (0.7–1.4)	1.1 (1.0–1.2)	1.0 (0.7–1.4)	1.8 (1.5–2.2)	1.1 (1.0–1.2)
Football							
Male incidence *n* (%)	1280 (7.8)	902 (5.5)	1745 (10.6)	9943 (60.4)	762 (4.6)	1836 (11.1)	16 468 (100)
Male incidence rate	2.2	1.6	3.0	17.2	1.3	3.2	28.5
Female incidence *n* (%)	398 (5.8)	333 (4.8)	570 (8.3)	4513 (65.4)	368 (5.3)	715 (10.4)	6897 (100)
Female incidence rate	1.7	1.5	2.5	19.7	1.6	3.1	30.1
Female versus male IRR (95% CI)	0.8 (0.7–0.9)	0.9 (0.8–1.1)	0.8 (0.7–0.9)	1.2 (1.1–1.2)	1.2 (1.1–1.4)	1.0 (0.9–1.1)	1.1 (1.0–1.1)
Gymnastics							
Male incidence *n* (%)	4 (1.9)	11 (5.2)	25 (11.8)	26 (17.1)	2 (0.9)	133 (63.0)	211 (100)
Male incidence rate	1.4	3.9	8.9	12.9	0.7	47.6	75.5
Female incidence *n* (%)	10 (2.1)	43 (9.1)	33 (6.9)	100 (21.1)	4 (0.8)	285 (60.0)	475 (100)
Female incidence rate	1.0	4.1	3.2	9.6	0.4	27.5	45.8
Female versus male IRR (95% CI)	0.7 (−0.5–1.9)	1.1 (0.4–1.7)	0.4 (−0.2–0.9)	0.7 (0.3–1.2)	0.6 (−1.1–2.3)	0.6 (0.4–0.8)	0.6 (0.4–0.8)
Handball							
Male incidence *n* (%)	409 (9.1)	375 (8.4)	1025 (22.8)	2039 (45.4)	153 (3.4)	488 (10.9)	4489 (100)
Male incidence rate	8.6	7.9	21.6	42.9	3.2	10.3	94.5
Female incidence *n* (%)	905 (8.0)	667 (5.9)	2374 (21.0)	5653 (50.0)	400 (3.5)	1306 (11.6)	11 305 (100)
Female incidence rate	8.3	6.1	21.9	52.1	3.7	12.0	104.2
Female versus male IRR (95% CI)	1.0 (0.9–1.1)	0.8 (0.7–0.9)	1.0 (0.9–1.1)	1.2 (1.2–1.3)	1.2 (1.0–1.3)	1.2 (1.1–1.3)	1.1 (1.1–1.1)
Swimming							
Male incidence *n* (%)	6 (3.2)	24 (13.0)	74 (40.0)	48 (25.9)	13 (7.0)	20 (10.8)	185 (100)
Male incidence rate	0.8	3.3	10.2	6.6	1.8	2.7	25.4
Female incidence *n* (%)	20 (7.9)	17 (6.7)	88 (34.9)	68 (27.0)	40 (15.9)	19 (7.5)	252 (100)
Female incidence rate	2.6	2.2	11.4	8.8	5.2	2.5	32.6
Female versus male IRR (95% CI)	3.3 (2.3–4.2)	0.7 (0.1–1.3)	1.1 (0.8–1.4)	1.3 (1.0–1.7)	2.9 (2.3–3.5)	0.9 (0.3–1.6)	1.3 (1.1–1.5)

million and NOK 46.9 million, respectively, during the period 2017 and 2020.

Calf/ankle/ft (56.7 per 1000 athlete years) and hip/thigh (36.5 per 1000 athlete years) had the highest incidence rates. Knee injuries accounted for both the highest mean cost and incidence in football (7337 NOK SD 17 693, 8.0 incidence per 1000 athlete years) and handball (7224 NOK SD 14 565, 27.1 incidence per 1000 athlete years). In gymnastics, knee injuries also had the highest mean costs (16 627 NOK SD 25 762) and a high incidence (4.5 per 1000 athlete years), whereas calf/ankle/foot had the highest incidence (4.7 per 1000 athlete years). In swimming, shoulder injuries had the highest incidence (8.9 per 1000 athlete years) (Figure 1).

Surgery accounted for the overall highest costs in all sports, with the highest numbers in handball (59.2%) and football (54.4%). Lower limb surgery accounted for 65% of the costs in handball and 58% in football. Costs for physiotherapy treatment were common in all sports, accounting for 14%–37.4% of total payment from the insurance companies, with a much lower cost for each claim compared to surgery. In gymnastics, 22.5% of the total costs were connected to permanent medical impairments, while this was uncommon in the other sports. In 36 cases, medical impairment was given; of these, 21 of the cases were from gymnastics.

3.4 | Injury Incidence and Costs During COVID-19 Pandemic

In 2020, the number of reported injury claims declined across all sports compared to pre-pandemic years, except for athletics, which exhibited a 14.4% increase in reported claims. The injury incidence in athletics and gymnastics was higher in 2020, with 45.7% and 10.1% increases, respectively. In contrast to football (−16.3%), handball (−9.7%), and swimming (−1.9%), where the incidence dropped (Table 4).

4 | Discussion

This study uniquely provides an opportunity to consider injury incidence rates; injured body region, costs and mean costs per 1000 athlete years using national insurance claim data across five sports for female and male athletes ages 13–50. The main findings of this study were that the highest injury incidence rates were found in athletics, followed by handball compared to football, gymnastics, and swimming. Lower extremity injuries had the highest incidence and mean cost per 1000 athlete years. More than one fifth of injuries in gymnastics gave permanent medical impairment. The impact of COVID-19 through its first year was a reduced number of licensed athletes in all five sports and a reduced number of injury claims in all sports except in athletics.

4.1 | Injury Incidence

Our overall injury incidence rates are higher than previous insurance data reports from Sweden [13–15] and from Australian netball [14]. The incidence in handball and football in the Swedish study was 63.4 and 17.2 injuries per 1000 athlete years compared to our numbers 101.2 and 29 per 1000 athlete years. However, the data from Sweden included only acute injuries and cases that gave reimbursement [13, 15], while our data includes both acute and gradual onset injury treatment costs. In addition, around half of the reported injuries did not give reimbursement, which might explain the difference.

The high injury incidence in athletics both during the first 3 years and especially during COVID-19 is both surprising and a concern. In an insurance study from Flandern [11], they reported 28.8 acute injuries per 1000 athlete years. Data from elite athletics during the European Championship in 2012 showed a much higher incidence, 98.4 injuries per 1000 registered athletes. The injury rates reported were higher in males and increased with age [16]. Even though our data represent the general athletic population, we found an incidence of 152 injuries per 1000 athlete years. Female athletes had an overall slightly higher injury risk than male athletes in our data. In a study among elite athletics, Jacobsen et al. [17] showed that 96% of the injuries were reported as non-traumatic (associated with gradual onset). The injury incidence among both youth and adult elite athletics athletes was high [17]. In our study, we were restricted to insurance claim data and the distribution between acute and gradual onset injuries is not available in the data; however, gradual onset injuries might be underestimated, an even greater concern for the high incidence reported in athletics in this study.

4.2 | Injury Incidence and COVID-19

Our data showed a reduced number of licensed athletes in 2020 compared to the previous seasons for all sports, and a reduction of injury cases in all sports except in athletics, where we found a 14.4% increase. Surprisingly, the injury incidence in athletics almost doubled compared to the previous years, with a 45.7% increase. This might be explained by less restriction in training and competition during 2020 since physical contact is not a part of athletics compared to team sports such as handball and football. In both handball and football, the COVID-19 pandemic resulted in a massive lockdown of activities. For handball, as an indoor activity, teams were without indoor training time for several months through 2020, and no specific handball training was performed, which could explain the reduced injury incidence in 2020. A reduction of all sports-related injury visits was found at Canadian Hospitals during the COVID-19 pandemic for all ages.

4.3 | Sport, Body Region and Female/Male Incidence Rate Ratio

Our data enhance the importance of implementing injury prevention measures among female handball and football players, especially for lower extremity injuries. Injury prevention programs exist and are effective [18–21], but the implementation of the programs in daily training is challenging [22–24].

Head and neck injuries were more prominent among handball players, showing no sex differences, while male players had a higher incidence in football. Since our data only give information

TABLE 3 | Incidence (number of injury reports), and incidence rates (incidence per 1000 athlete years) for male/female and incidence rate ratio (IRR) between female and male in each sport sorted by age groups.

Age groups	Athletics	Football	Gymnastics	Handball	Swimming
13–19 years					
Incidence (*n*)	1280	13 620	570	10 362	386
Incidence rate male	109.0	32.9	73.0	80.6	29.2
Incidence rate female	119.9	36.0	51.7	90.0	33.8
IRR (95% CI)	1.1 (1.0–1.2)	1.1 (1.1–1.1)	0.7 (0.5–0.9)	1.1 (1.1–1.2)	1.2 (1.0–1.4)
20–25 years					
Incidence (*n*)	695	5207	76	2931	29
Incidence rate male	336.1	52.5	115.4	179.9	17.1
Incidence rate female	408.9	57.2	107.8	187.0	29.3
IRR (95% CI)	1.2 (1.1–1.4)	1.1 (1.0–1.2)	0.9 (0.5–1.4)	1.0 (1.0–1.1)	1.7 (1.0–2.4)
26–50 years					
Incidence (*n*)	637	4538	40	2501	20
Incidence rate male	134.1	15.7	20.0	94.1	7.5
Incidence rate female	198.5	11.9	19.4	130.3	21.9
IRR (95% CI)	1.5 (1.3–1.6)	0.8 (0.7–0.8)	1.0 (0.4–1.6)	1.4 (1.3–1.5)	2.9 (2.0–3.8)

on body region with no specific diagnosis, concussion might be included in these data; concussion is a concern in both football and handball [25, 26].

In swimming, up to 40% of the injuries were located in the upper extremities, and approximately 22% in handball, with no sex differences. A review of swimming injuries reported a high prevalence of shoulder injuries, mainly due to overuse [27]. In handball, both acute and gradual onset injuries are reported [28]. The insurance in Norway covers gradual onset injuries, and we might hypothesize that especially injuries to the shoulder in swimming could have a gradual onset nature. Overall, prevention efforts should be prioritized in all sports for both genders.

4.4 | Mean Cost Per 1000 Athlete Year

The highest mean cost per 1000 athlete years was found in gymnastics and football in the lower extremities. Surgical costs were high across all sports, with handball and football accounting for a substantial portion, comprising 59.2% and 54.4% of the aggregate disbursements by insurance providers, indicating a heightened prevalence of severe injuries within these sporting disciplines. It is likely that the costs associated with surgical procedures, such as ACL reconstructions, contribute significantly to the overall expenses for severe knee injuries. The insurance companies cover these procedures in private hospitals, enabling athletes to expedite their surgical treatment. Given that both handball and football players are at a heightened risk for ACL injuries, these figures underscore the critical need for prevention measures that specifically target lower extremity injuries. This is in line with insurance data from both Australia [14, 29] and Sweden [30].

4.5 | Methodological Considerations

One of the strengths of this study is the large sample size, which includes all licensed athletes from five sports in Norway over 4 years, including 1 year during the COVID-19 pandemic. Since all athletes are required to have a license to participate in organized sports, this study uniquely provides a comprehensive picture of sport injuries in both team and individual sports including injury incidence rates, injured body region, and mean cost per 1000 athlete year. Another strength is that injury definitions and data collection procedures were consistent across all included sports, allowing for comparisons across sports, sexes, and ages. Data from a Swedish insurance company have shown that insurance databases provide relatively high-quality data.

Most injury claims in this study were for injuries that resolved without medical assistance, which is consistent with data from New Zealand [31]. As only approximately 50% of injury claims resulted in reimbursement, many of the injuries were likely minor and did not require visits to the healthcare system or incurred costs for the athlete. Furthermore, with insurance companies enforcing a co-payment of NOK 1000, the number of claim reimbursements has been reduced. However, a study of ACL injury rates in Sweden found that only 74% of injuries were reported to the insurance company, indicating a possible underestimation of severe injuries [32]. Additionally, severe injuries may not be reported if they are treated directly by the national health system. This is also the case for children who have

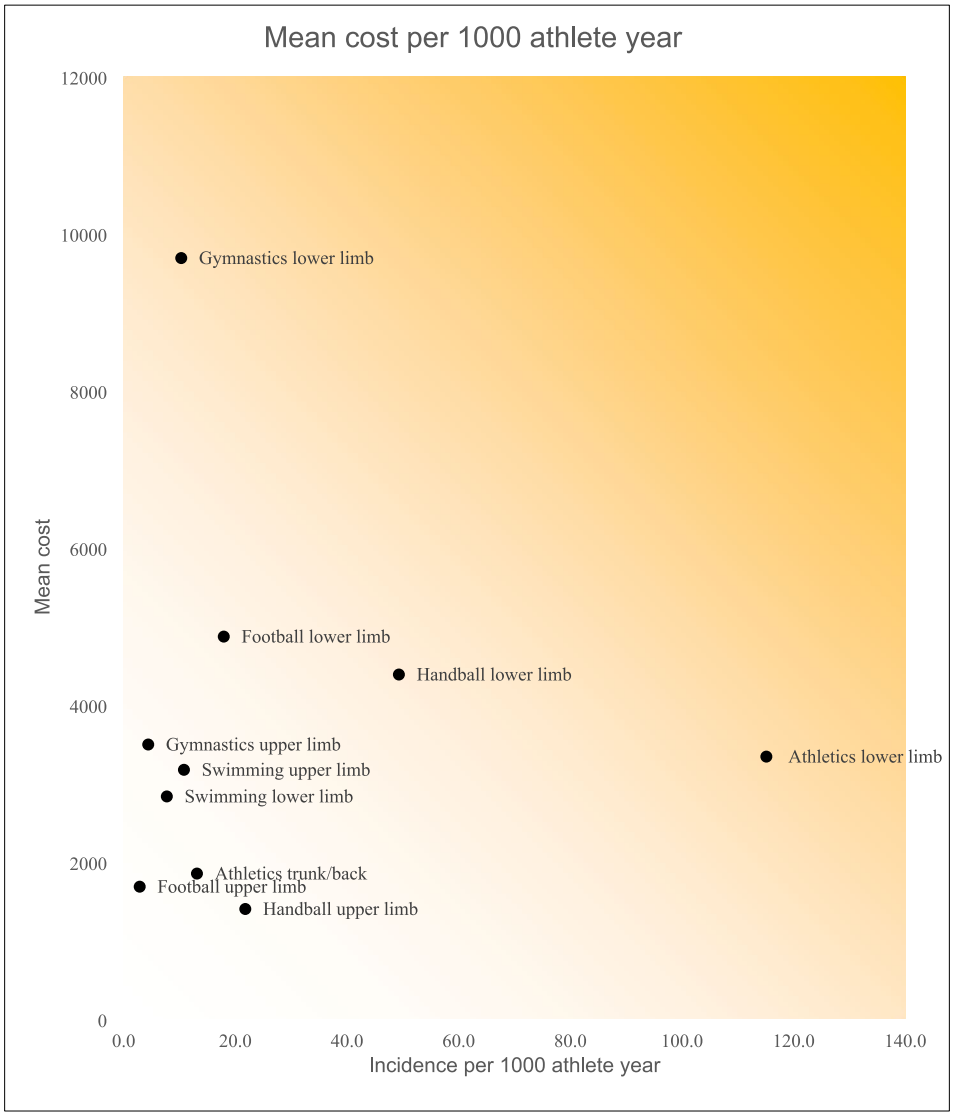

FIGURE 1 | Mean cost per 1000 athlete year for the two most common injured body regions (highest incidence per 1000 athlete year) from each sport.

access to the health system, physicians, physiotherapy, and dental treatment, with no costs up to age 16. Furthermore, the use of private insurance has increased in the last decade, resulting in a possible underestimation of severe injuries in this dataset.

Moreover, elite athletes may be more reluctant to register injuries since the club or federation has their own health service and sees no need for insurance involvement.

Comparison of information from insurance claims in Australia and Sweden with a standardized guide and consensus reports for injury registration found that most of the necessary information for injury surveillance was included [33, 34]. In the research from Åman [34] they concluded that insurance databases can be used as a basis for research on acute injuries in organized sports. The data is valuable to pinpoint areas where preventive measures should be targeted. Furthermore, it might serve to evaluate the efficacy of injury prevention initiatives at a national level [34].

However, using insurance data has limitations, as information on injury mechanism and specific diagnosis is not available; only data on body region is provided. Moreover, it is unclear whether an injury is new, recurrent, or an exacerbation of a previous injury. Analysis of incidence based on training exposure instead of per 1000 athlete years would have improved the data; however, this has not been possible in this dataset [35]. In addition, we do not have data that sort out if the payment from the insurance company was related to acute or gradual onset injuries.

Bahr et al. [36] advocate for a focus on the overall burden of injuries and illnesses, rather than solely on their incidence. In the present study, we did not record time-loss from sporting activities; therefore, we have presented mean costs per 1000 athlete years as our "burden estimate" (Figure 1), which is based on insurance company reimbursement costs. This approach differs from the recommendations outlined in the consensus statements by Fuller et al. [37] and Bahr et al. [12] which emphasize

TABLE 4 | Incidence (number of injury reports), Incidence rate (incidence per 1000 athlete year) and total cost (in NOK) for insurance companies per year 2017–2020.

	Athletics (n = 2612)		Football (n = 23 365)		Gymnastics (n = 686)		Handball (= 15 794)		Swimming (n = 437)	
Year	**Incidence**	**Costs**	**Incidence**	**Costs**	**Incidence**	**Costs**	**Incidence**	**Costs**	**Incidence**	**Costs**
2017	127.1	1 751 197	29.2	21 295 539	36.7	576 328	93.6	10 587 777	28.3	314 088
2018	141.0	2 150 515	29.7	25 190 696	57.2	879 655	100.2	13 291 646	30.1	211 936
2019	141.6	2 075 915	30.9	23 839 736	54.8	834 874	110.6	13 421 860	29.3	370 203
2020	206.3	2 421 137	25.9	20 453 730	60.3	619 741	99.9	9 579 680	28.7	258 260
Total	151.7	8 398 764	29.0	90 779 701	52.0	2 910 598	101.2	46 880 963	29.1	1 154 487

the use of direct time-loss data. As a result, comparisons with other studies reporting "injury burden" may be limited [38–40].

Based on costs only, our findings demonstrated that knee injuries resulted in the highest reimbursement in handball, football, and gymnastics, consistent with insurance data from several countries and sports. In Australian sub-elite football players, severe knee injuries, mostly ACL ruptures, were the costliest injury [29]. This is also consistent with data from Swedish sports, where knee injuries were most common in all ball sports and in female ice hockey [30].

Children and youth under age 16 do not pay for most health services in Norway, such as visits to a physician, surgical treatment, physiotherapy, and dental treatment, which partly could explain the large number of claims that did not give reimbursement. In addition, it may hide/cover the real costs for sports injuries. Moreover, we only had information on direct healthcare costs, leaving out indirect healthcare costs such as loss of productive output or productive loss due to disability, which can be a substantial burden for the athlete, the team, the sports organization, and the wider community [10].

5 | Perspectives

The highest injury incidence rates were found in athletics followed by handball compared to football, gymnastics, and swimming. Injuries to the lower extremities had the highest incidence and mean cost per 1000 athlete years. Surgical interventions accounted for over half of the costs in both handball and football. More than one-fifth of injuries in gymnastics resulted in permanent medical impairment.

The impact of COVID-19 through its first year was a reduced number of licensed athletes in all five sports and a reduced number of injury claims in all sports except in athletics. The results enhance the importance of injury prevention measures in general and especially for lower extremity injuries in handball and football.

Author Contributions

All authors were involved in the study design. K.N. was responsible for the data collection. G.M. took the lead in drafting the manuscript, while all authors critically reviewed the paper and approved the final version.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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