

Paper II

Childhood Fractures in Bergen, Norway: Identifying High-Risk Groups and Activities

*Christina Brudvik, MD, and †Leiv Magne Hove, MD, PhD

Study conducted at Bergen Accident and Emergency Department and Haukeland University Hospital, Bergen, Norway

Summary: In 1998 the authors conducted a prospective registration of children younger than 16 presenting with a new traumatic fracture in the city of Bergen, Norway. In this epidemiologic study, the authors registered a total of 1,725 fractures in children; the fracture incidence was 245 per 10,000 children below the age of 16. One fifth needed reduction, and the distal radius was the most common fracture site (27%). Activities associated with fracture were mostly soccer and bicycling, but compared with the total number of injuries associated with each activity, we found a doubled risk of fractures

during rollerblading/skating or snowboarding (60%) compared with playing soccer (38%) or bicycling (33%). Scaphoid fracture, an infrequent fracture in children, was seen in 9% of all fractures due to rollerblading/skating. There was a doubled risk of fracture in boys aged 13 to 15 compared with their female peers. To make fracture prevention more efficient, it should be targeted at this risk group and these high-risk activities. Protection of the wrist region might prevent the most common fractures. **Key Words:** child fracture, wrist protection, scaphoid

Children need physical activity to develop normal motor abilities and to reduce tension and stress.¹¹ Overweight and physical inactivity are increasing health threats to children in the developed world.^{5,7} The introduction of new, exciting sporting activities to children is an important means to encourage physical activity but will also need favorable conditions to lower the risk of injury. A continuous injury registration to identify special risk factors and propose improvements or restrictions is important as a responsible follow-up of both old and new activities among children.

Injuries in children reflect the pattern of their physical activities. Because fractures usually come to medical attention, the registration of this injury type would give good information. Fracture is a common injury in childhood.^{1,3,13,14} Children's carefree playing and the fact that their bone is growing make them vulnerable to skeletal injury. Children's fractures heal in a shorter time than those in adults, and many deformities correct themselves spontaneously. Fractures are, however, painful, they may cause growth disturbances or secondary deformity, and they may even be fatal. The management of complicated childhood fractures is improving, and new surgical tech-

niques aim at shortening the immobilization period.² Still, many children lose weeks of school and physical activity due to fractures.¹³

We wanted to learn how and in which situations fractures occurred in our society compared with other geographic regions. The city of Bergen, Norway, had no earlier fracture registration for comparison. Comparing data is important to reveal the most common and serious injuries associated with different activities. We wanted to analyze which injury mechanisms and activities caused the same fracture types so as to have a basis for preventive recommendations. When encouraging children to be physically active, it seems important to give adequate recommendations for the use of preventive means. Cost/benefit evaluations and the efficacy of injury prevention also demand the identification of children at risk for injury. In the same way that preventive medicine identifies high-risk patients to reduce morbidity, injury prevention must be targeted toward high-risk groups and high-risk activities.

MATERIALS AND METHODS

Bergen is located on the western coast of Norway and is the second largest city after Oslo. Bergen had 227,250 inhabitants in 1998, and the population below the age of 16 was 47,750. Bergen Accident and Emergency Department (AED) (Bergen Legevakt) is in the central part of the town and treats most of the minor injuries. Haukeland University Hospital is the regional hospital receiving all major injuries and multiply injured patients.

From *Bergen Accident and Emergency Department and †Haukeland University Hospital, Institute of Surgical Sciences, University of Bergen, Bergen, Norway.

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Address correspondence and reprint requests to Christina Brudvik, Bergen Legevakt, PO 4500, 5838 Bergen, Norway (e-mail: christina.brudvik@kir.uib.no).

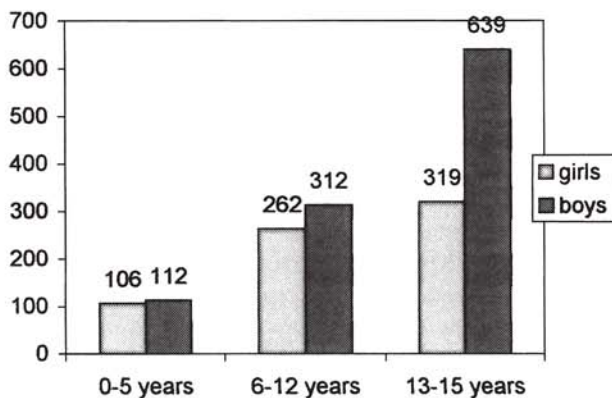


FIGURE 1. Incidence of fractures per 10,000 children.

In 1998 a total of 7,041 new injuries on children below age 16 were registered, of these 732 at Haukeland University Hospital. We found that 5,468 were inhabitants of Bergen, while the rest came from surrounding municipalities.

The study of all new traumatic fractures was carried out as a prospective registration on children below age 16. Data were recorded over a 12-month period from January 1 to December 31, 1998. All patients or their parents received a standard questionnaire about the current accident, earlier accidents and fractures, and whether they thought the fracture could have been prevented by the use of safety devices. The attending physician answered additional questions regarding the severity of the fracture and whether it needed reduction. All data were registered directly into each patient's own computerized medical record on a separate screen page (Infodoc patient data system). Data from the screen page, including the year of birth, sex, and community number, otherwise anonymous, were transmitted to the Epi Info statistical program.⁶ Information from Haukeland University Hospital was collected manually from questionnaires handed out to patients or their parents containing the same anonymous data.

The data were analyzed by the authors using the Epi Info statistical package. The results are given as means with 95% confidence intervals (95% CI). Chi-square

tests were used when appropriate. The level of significance was set at 5% ($P < 0.05$).

RESULTS

We registered a total of 1,725 fractures, and 363 of them (21%) needed treatment with closed or open reduction. Boys sustained 59% of all fractures. In terms of fractures that needed reduction, the frequency of boys increased to 62%.

The overall annual fracture incidence was 245 per 10,000 children under 16 years of age. Girls aged 13 to 15 had an incidence of 319 per 10,000, while boys had an incidence of 639 per 10,000 (odds ratio [OR] 2.07, 95% CI 1.80–2.38, $P < 0.001$). In children age 6 to 12, girls had an incidence of 262 per 10,000 and boys 341 per 10,000 (OR 1.31, 95% CI 1.11–1.55, $P = 0.001$). In the youngest children (>6 years of age), girls had an incidence of 106 per 10,000 and boys 112 per 10,000 (OR 1.06, 95% CI 0.80–1.39, $P = 0.17$) (Fig. 1). Only at age 10 did girls have more fractures than boys (respectively 80 and 68; Fig. 2). Girls at this age acquired fractures playing soccer (14%) or handball (13%) and boys when playing soccer (19%) or bicycling (13%).

Of all children injured in 1998, 20% had a history of earlier fractures. In children 6 to 15 years old, 26% had a history of earlier fractures, while 36% of the 580 children aged 15 had an earlier history of fracture (OR 1.57, 95% CI 1.3–1.89, $P < 0.05$).

Fractures in children under 6 years old ($n = 327$) mostly happened indoors at home (32%, $n = 88$), followed by outdoors near home (23%, $n = 63$) and outdoors in kindergarten (17%, $n = 47$) and other playgrounds (7%, $n = 19$). Fractures in schoolchildren ($n = 1,398$) happened outdoors near home (28%, $n = 349$), followed by outdoors at school (20%, $n = 243$), indoor at school, mainly in school gymnastics (10%, $n = 127$), and on playgrounds (6%, $n = 80$). Organized sports involved 11% ($n = 130$) of the fractures, equally divided between indoor and outdoor activities.

The activities associated with fractures were soccer ($n = 205$), bicycling ($n = 123$), handball, volleyball, and basketball ($n = 90$), and rollerblading/skateboarding (n

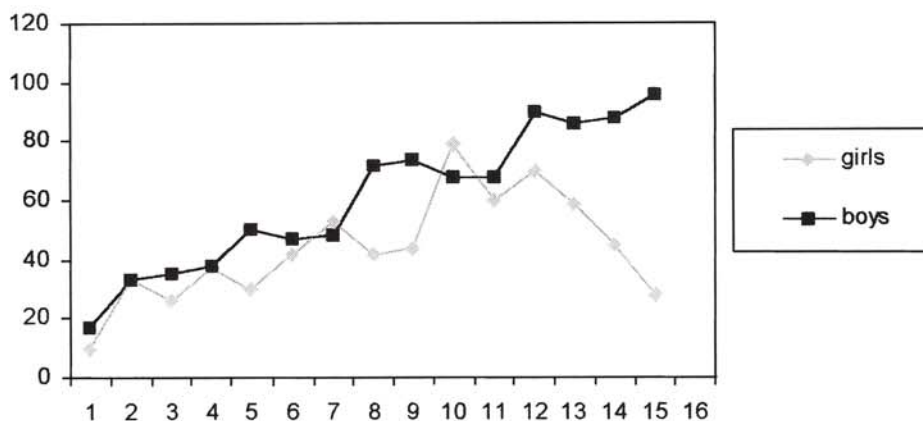


FIGURE 2. Number of fractures by age in years.

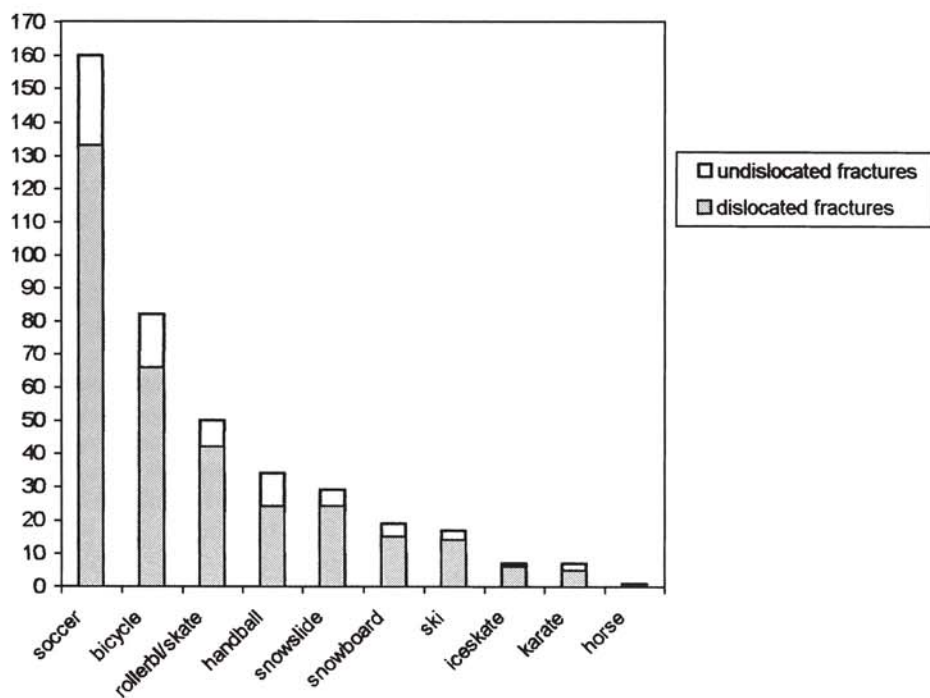


FIGURE 3. Number of male fractures in different sporting activities.

= 67) (Figs. 3 and 4; Table 1). The percentage of fractures related to the total number of injuries associated with each activity showed a doubled risk of fracture when rollerblading, skateboarding, or snowboarding (60%) compared with bicycling (33%) or playing soccer (38%) (OR 2.50, 95% CI 1.73–3.60, $P < 0.05$).

The attending physicians registered child abuse in four children with fractures involving the metacarpal, clavicle, radial, and femoral shaft bones (2.8 per 10,000). Deliberate violence, including fighting, caused 13 children (9 per 10,000), 12 of them boys, to acquire metacarpal, finger, or nose fractures. Three boys punched walls in frustration, acquiring metacarpal fractures. Physical contact, including pushing, kicking, and holding during sports or play, was the reason for injury in 14% of the fractures ($n = 195$).

More than two thirds of all fractures involved the upper extremity (70%). The number and location of the fractures are shown in Figure 5 and Table 2. We will

briefly describe the characteristics of the different fracture locations.

Fractures of the radius and ulna

The distal radius was the most common fracture site ($n = 461$), involving 27% of all fractures. The greenstick type of fracture dominated with 56% ($n = 258$), the Colles type 20% ($n = 90$), physeal fractures 19% ($n = 87$), and the Smith type 5% ($n = 22$). Eleven percent required open or closed reduction. Of the 218 fractures of the middle and upper forearm, 55% needed closed and 3% open reduction. Twelve patients, eight of them girls, had fractures of the radial head. Soccer accidents more often involved the arms than the legs and caused most of the distal radial fractures (16%). Rollerblading/skateboarding involved 8% and bicycling 7% of the distal radial fractures. Falls from bicycles caused half of the Smith type of distal radial fracture because of landing on volarly flexed wrists ($n = 11$).

FIGURE 4. Number of female fractures in different sporting activities.

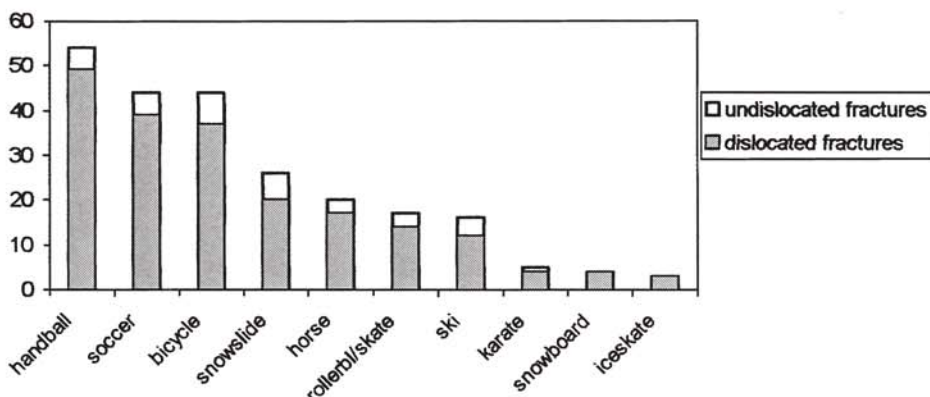


TABLE 1. Most common fracture locations by sport

	Distal radius	Forearm	Hand/fingers	Humerus	Foot/toes	Clavicle	Tibia/fibula	Ankle	Number
Soccer	39%	7%	20%	2%	10%	3%	1%	8%	205
Bicycle	34%	16%	16%	6%	4%	10%	1%	0%	123
Handball/volleyball/basketball	16%	12%	60%	0%	4%	1%	0%	2%	90
Rollerblades/skates	57%	9%	15%	3%	1%	6%	6%	1%	67
Snowslide	18%	11%	5%	5%	4%	18%	25%	2%	55

Fractures of the hand

We found 225 children with finger fractures, and 61 (27%) needed treatment by reduction. Handball, volleyball, or basketball was the cause in 26% and soccer in 16% of these fractures. Blows against fingers, especially from balls (31%), falls on the ground (22%) and pinching, especially in doors (19%), were common injury mechanisms. Intentional violence caused 1.7% of these fractures. The 69 metacarpal fractures happened in activities such as soccer (14%), bicycling (11%), and handball, volleyball, and basketball (8%); metacarpal fracture was also the most common fracture associated with fighting and violence ($n = 5$), involving 7% of these fractures. Three boys (4%) aged 13 to 15 punched their fists into the wall in frustration, acquiring a fracture. Four of 10 metacarpal fractures occurred at school. Scaphoid fractures ($n = 17$) were the most common carpal fracture ($n = 24$) and were caused by a fall on rollerblades/skateboard ($n = 6$), a fall in soccer ($n = 3$), and other falls or hits ($n = 8$). The two youngest patients were 12 years old, and two were girls. The fractures were either distal avulsions or fractures in the distal third of the scaphoid bone.

Fractures of the foot

Most children had metatarsal fractures ($n = 95$), while 74 had toe fractures. The metatarsal fractures were due to stumbling on the ground (50%) or fall/jumps from

heights (35%). Two children had metatarsal fractures caused by car wheels. Toe fractures were due to soccer playing (22%), pinching/squeezing (21%), or blows (33%). Five (7%) needed to be reduced. Fractures in the rest of the foot comprised six, two in the navicular bone due to jumping on a snowboards and in basketball, and two in the cuneiform bone due to jumping on a trampoline and a snow sliding collision. Fall from heights caused a calcaneus and a talus fracture.

Fractures of the clavicle

This fracture type involved 138 children (8% of all fractures). Downhill sledging in the winter caused 8% and falls from bicycles caused 10% of these fractures. Half of the children were below 6 years of age. Indoor fall from heights, especially from beds, bunk beds, and chairs, involved 24 children.

Fractures of the humerus

These included 63 supracondylar and 16 epicondylar fractures of the humerus. All were due to falls, mostly from heights, and 20% fell from swings near home or on playgrounds. Eight of ten patients were 2 to 9 years old; boys and girls equally (30:31) had supracondylar fractures, while boys had more epicondylar fractures (13:3). One third of the fractures needed reduction. Girls had more fractures of the proximal end of the humerus (19:2); one third were caused by fall from a horse ($n =$

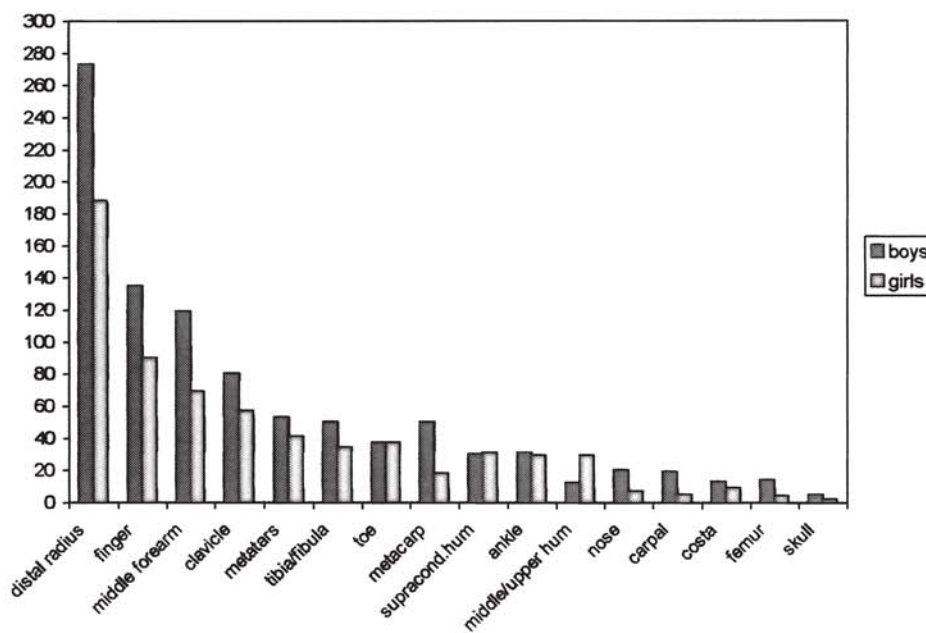


FIGURE 5. Number and site of fractures in boys and girls.

TABLE 2. Most common fracture locations

	n	%
Distal radius	461	27
Hand (phalanges 225, metacarpal 69, carpal 24)	318	19
Forearm	218	13
Foot (phalanges 74, metatarsal 95, tarsal 5)	174	10
Clavicle	138	8.0
Tibia/fibula	83	4.8
Supracondylar humeral	79	4.6
Ankle (lateral malleolar 48, medial malleolar 13)	61	3.5
Shaft and proximal humeral	44	2.6
Facial skeleton	32	1.9
Femur shaft	18	1.0
Radial neck/head	12	0.7
Skull	7	0.4
Total	1,645	96.5

6). There were 20 fractures of the humeral shaft, mostly due to falling accidents but also to snow sliding.

Fracture of the tibia and fibula

Fourteen (17%) of the 83 children who broke their tibial/fibular bone did so in snow sliding collisions. Seven said they had hit obstacles in the snow-sliding area, such as fences and benches. Toddlers represented more than one third of fractures in these bones. Two had squeezed their ankles under the foot end of a stroller; one child fell 10 m from an open window, sustaining an angulated tibial/fibular fracture; and two had tibia fractures due to bicycle collisions with cars.

Fractures of the ankle

Fractures of the ankle (n = 61) mainly occurred while playing soccer (30%). Half of the patients were girls. We found 48 fractures of the lateral malleolus and 13 of the medial. Six needed reduction.

Fractures of the femur

Fractures of the femur involved 18 children (1% of the fractures). Two boys, 11 and 14 years old, with physical handicaps sustained their femur shaft fractures during transfer and training in daily care. Four children under 1 year of age with shaft fractures were injured by falling from bed, bathinette, out of an adult's arms and by an adult falling over the child. Six femoral condyle and shaft fractures occurred in boys aged 8 to 12 during activities such as slalom, soccer, and snow sliding collisions.

Fractures of the facial skeleton and skull

Twenty-seven children had nasal fractures; almost 80% were boys. Two were due to deliberate violence. Five had mandibular fractures due to a fall. Seven children had cranial fractures; four occurred during bicycling and one during snow sliding. Two of them had intracranial bleeding and one died.

Other fractures

Twenty-two children sustained costal fractures, and two were hospitalized because of suspected internal injury due to a fall while mountain climbing and a collision during snow sliding. Falls during bicycling, snow sliding, and soccer were other causes. Two children had

scapular fractures, two had pelvic fractures, and one had a stable neck fracture from a car accident. One compression fracture in the lumbar spine was due to a snowboard-related fall.

DISCUSSION

Bergen had no earlier child fracture registration to compare with, but in Malmø, Sweden, a twofold increase in fracture incidence in children below 17 was found from 1950 to 1979 to a yearly incidence of 212 per 10,000.¹⁴ The increase was mainly in minor sports-related fractures. A follow-up study in 1993 and 1994 showed a decreasing fracture incidence to 193 per 10,000.²⁰ We found a higher fracture incidence, 245 per 10,000, in our child population. In the meantime, rollerblading and skateboarding activities have increased in popularity in Norway, and they seem to cause a higher proportion of fractures than other activities.¹ A study of the incidence and causes of fractures in European districts in 1996¹⁷ showed a much higher fracture incidence in children aged 0 to 14 years in south Wales (360 per 10,000) than in the Scandinavian countries (156 per 10,000). This was explained by the higher rate of soccer-, rugby-, and rollerblading-related fractures. The higher risk associated with winter sports in Scandinavia was outweighed by the risk associated with these other activities performed for a greater part of the year in the milder climate of south Wales.

Soccer dominated as a cause of fracture with 15% in schoolchildren in our registration (n = 205). Three fourths of the fractures were located in the upper extremity, making it logical to protect the wrist region as well as the shin when playing soccer.¹⁶ Alpine sports injuries were not very numerous in the present study, involving 30 ski-related and 23 snowboard-related fractures, but the number of injuries from snowboarding is increasing according to other Norwegian registrations.^{18,21} As with snowboarding, almost two thirds of the injuries associated with rollerblading and skateboarding were fractures. The distal radial site dominated with 57% of the fractures, but also scaphoid fractures, an otherwise rare fracture in children, were seen in one tenth of the fractures from rollerblading and skateboarding. Wrist guards were seldom used, but 27% of the injured thought that this type of protection could have prevented the fracture. Fractures in the wrist region constitute 40% of all injuries associated with rollerblading and skateboarding. Protection of this region would therefore reduce most injuries. Whether the wrist guards in use today fulfill this function is still debated. Forearm fractures just above the brace have even been reported as a side effect.⁴ Cadaveric studies indicate that wrist guards may have a preventive effect on low-energy trauma, but with too-rigid brace systems to absorb higher amounts of energy, the risk of creating stress points is high.⁸ A large multicenter case-control study from the United States showed a significant benefit for rollerbladers to use wrist guards.¹⁹ Similar protection with a volar, deformable, aluminum support significantly prevented wrist sprains in snow-

boarding injuries in a Norwegian prospective, clinical study of 5,029 snowboarders.¹⁸

During the early snowfall of February and March 1998, every second child attending the AED had injuries related to snow sliding. Improved snow-sliding fields could prevent many tibial/fibular fractures resulting from hitting obstacles.

Comparing the total number of all bicycle injuries (including fractures) in children under the age of 16 in 1998 with a registration of bicycle injuries in Bergen in 1990–91,⁹ we found a significant decrease in the injury incidence from 93 to less than 80 per 10,000 ($P = 0.019$). Better bicycle tracks might be a reason, but perhaps fewer children bicycled in 1998 than 8 years earlier. Four had skull fractures due to bicycling in our study, but we obtained no information regarding their use of helmets. A Danish study including 409 children with head injury related to bicycling found that the use of helmets decreased the risk of brain injury significantly but had no effect if motor vehicles were involved.¹⁵

Women in Bergen aged 60 to 69 have the highest reported age-specific incidence of distal radial fractures in the world.¹² In the older age groups this incidence decreased, making low bone mineral density a less important factor. A considerable seasonal variation was found, with a significantly higher fracture incidence on days with snow on the ground. Fall injuries are common because of the Bergen climate: temperatures vary from above to below zero during the winter months, causing sudden changes in icy and wet ground conditions. Children also fall on icy ground, but the incidence of children with radial fractures in our region does not differ from regions with a different climate.¹⁷ The youngest children acquired most fractures due to falling accidents indoors at home, but in the total child population, 72% of fractures happened outdoors.

Injuries reflect the pattern of activities in children, and sports clearly dominate as the main cause of fracture. Boys aged 13 to 15 had a doubled risk of acquiring a fracture compared with their female peers. This difference between the sexes decreases with decreasing age, but boys still dominate at all age groups, except around the age of 10. Girls injured playing soccer and handball was the reason for this. The only fracture type that was more common in girls was in the upper humeral bone, most often due to a fall from a horse. These findings correspond to similar findings in other studies.^{10,14}

CONCLUSIONS

Boys aged 13 to 15 run the highest risk of acquiring fractures, and this group should be the target for most preventive efforts. Rollerblading, skateboarding, and snowboarding activities carry the highest fracture risk, and soccer causes the most fractures. The wrist is the

major fracture site, so protection of this area would be the best preventive advice to recommend in all these activities.

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