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Fracture Patterns in Children

Analysis of 8,682 Fractures with Special Reference to Incidence, Etiology
and Secular Changes in a Swedish Urban Population 1950-1979.

BY

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INTRODUCTION

The main purpose of fracture epidemiology as well as epidemiological studies in general is to find the etiology of disease or at least a direction in which to search for the etiology. Studies on fracture epidemiology have, so far, been almost entirely limited to adults and have dealt with the etiological factors that cause loss of bone mass with age and with fragility fractures such as fracture of the upper end of the femur and the humerus, vertebral crush fractures and fracture of the distal end of the forearm (Buhr & Cooke 1959, Bauer 1960, Alffram & Bauer 1962, Alffram 1964, Horak & Nilsson 1975, Nilsson & Westlin 1977). It has been possible to point out several etiological factors such as various types of disease and medication, gastric resection, alcoholism, arrhythmia and parity (Nilsson 1969, Nilsson 1970, Lidgren & Wallöe 1977, Abdon & Nilsson 1980, Kristensson et al. 1980).

Fractures in children have in this respect attracted very little attention. Even if the literature describing accidents in children is abundant and fracture rates are usually calculated, the denominator - the population at risk - has generally not been known or at least not used and incidence numbers are therefore not available. One exception is Wong (1965), who knew the population at risk for his data, not only by age, sex and number but also by ethnic group. Also, Kärrholm et al. (1982) described the incidence of ankle and tibia fractures in children. In work concerned with accident prevention in children the measurement of results - the monitoring procedure - is complicated by variations in the population at risk and also by the attitudes towards accidents within the medical society (particularly those accidents without severe consequences) and by the availability and organization of the medical services. Registration routines are also of importance (Berfenstam 1957, Gustafsson 1972). Apart from mortality, fractures are probably one of the most reliable parameters of danger factors in the lives of children. It would also be of interest to investigate factors other than trauma that may influence or modify the fracture patterns in children.

The objective of this epidemiological study was, in a population previously used for studies on fracture epidemiology, also to include children in an attempt to analyse the age and sex specific incidence of common fractures, the contributory factors and, if possible, the secular changes in the population at risk.

Specific issues to be addressed were:

1. Has there been any trend of change in the incidence of fractures in children such as has been found or suspected in some fractures in adults?
2. Is the trend of change, if any, limited to specific fracture types or is it a general phenomenon?
3. Do the fracture patterns or pattern changes suggest changes in the exposure of children to risks?
4. Do children, in analogy with adults, present fracture patterns indicating bone fragility in individual subjects?
5. Do fracture-prone children exist?

MATERIAL AND METHODS

Population at risk

Malmö, situated in Southern Sweden, is the third largest city in the country with 235.111 inhabitants on January 1st, 1980. The city is a centre of industry and commerce and located in a low land region of old farming country. The weather conditions are of a coastal type with an annual average precipitation of 600 mm:s, most of which is rain. The winters are usually mild and there is only occasionally snow for short periods. The city area is 154 km² with a population density of 1,527 inhabitants/km². On January 1st, 1980, the juvenile population below the age of 17 years was 41,553; 18 per cent of the total number of inhabitants of the city. The population has decreased slightly over the years, in spite of the fact that a partly rural surrounding area with a total population of approximately 9,000 has been incorporated. The loss is mainly due to housing policy - to find their own homes young families have moved to suburban areas served by other hospitals. There have also been changes in the population of growing individuals, age 16 or less, for the same reasons and because of lower birth rates (Figure 1). During the years 1975 - 1979 the population of children in the city was composed as demonstrated in Figure 2 and Table A:I.

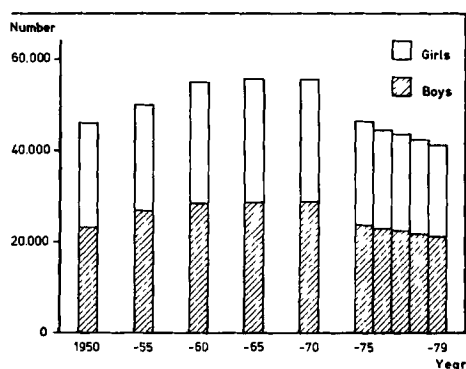


Figure 1. Number of children in Malmö 1950-1979.

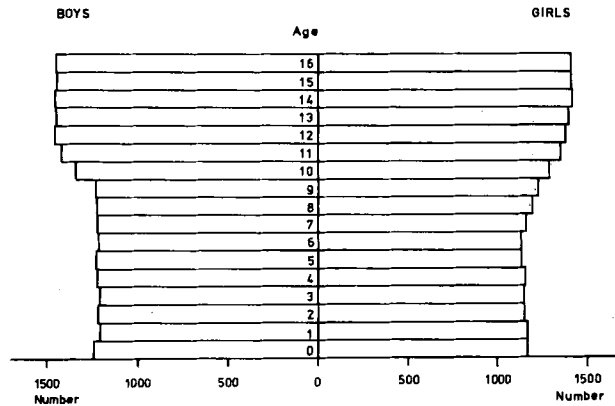


Figure 2. Average annual age and sex distribution of children in Malmö 1975-1978

For more than a decade the population of the city has been continuously monitored so that the age and sex distribution is available for any single year. Before that, however, there was a population census every five years. For the purpose of this study data from 1950, 1955, 1960 and 1965 has been used.

Hospital facilities

The Department of Diagnostic Radiology and the Emergency rooms of the General Hospital in Malmö serve the population of the city of Malmö in practically all cases of medical emergencies. In the Department of Diagnostic Radiology the roentgen films are classified according to the outcome of the diagnostic procedure - all fractures receive their own code letter and are then filed according to the organ system or anatomical location. The radiological record room also contains all the roentgen referrals to the Department from 1950 onwards with short case histories and descriptions of the causal trauma. Surgical procedures and autopsies are also reported and stored in this register. There are, however, several other roentgen diagnostic units in the city: in the Geriatric and Psychiatric Hospitals and in two private offices, all with a fair turnover of examinations. No

children were examined in the Geriatric or Psychiatric Hospitals, and in the private offices emergency trauma in children is rarely treated and fractures in children are practically always referred to the General Hospital.

Data collection procedure

The registers were searched for fractures in individuals of 16 years of age or less, residents of the city of Malmö, for information with regard to fractures and the following facts were noted:

Age at fracture
Sex
Type of fracture
Fracture side
Type of trauma
Environmental factor
Severity of trauma
Treatment
Concomitant disease
Accumulated number of fractures
Recent fracture on the same site

In many instances the information could, however, not be obtained from the record room of the Department of Diagnostic Radiology. In such cases the films were also reviewed and the record rooms of the Departments of Orthopaedic Surgery, General Surgery, Plastic Surgery, Hand Surgery and ENT were searched. Also, when the fracture type and localization could not be determined from the written report the films - virtually all films were available - were reviewed. Whenever the original fracture diagnosis was uncertain, the films were reviewed by a radiologist*. In this search, a better than 90 per cent completion of the data was achieved.

Specification of fractures

Bilateral fractures of the same bones of both limbs were recorded as two fractures. Two fractures of the same bone were recorded as one fracture and fractures of e.g. the radius and the ulna of the

* *C.G. Cederlund, M.D. and Holger Pettersson, M.D.*

same arm, again, as one fracture. Multiple fractures of the small bones of the hand and foot were recorded as one fracture regardless of the number of fractured phalanges - the carpal and the metacarpal bones were taken together and one or more fractures of these bones in one hand were recorded as one fracture. The exception was the scaphoid bone for which fractures were recorded separately. In the foot, the os calcis and the talus have been recorded separately, whereas other tarsal bones and the metatarsal bones were taken together. Fractures of ribs and teeth were not studied.

Classification of trauma severity

The severity of the trauma was classified as slight, moderate or severe:

Slight: The injury was caused by forces exerted by the injured individual: typical is falling to the ground from standing on the same level. However, to this group were also referred most of the sport injuries which are usually of a low energy type in children, e.g. ball sports, skating, skiing, wrestling, judo, karate and gymnastics but not falls from heights. Skateboard and roller skating injuries were also included in this group together with most playing injuries, including playground scuffles, but also falling from less than 0.5 metre (falling from stools, chairs or beds). It must be recognized that since this is a retrospective study the degree of violence was difficult to evaluate in many instances and impossible in others.

Moderate: Falling from between 0.5 - 3 metres or trauma caused by such velocities as those involved in falling from a bunk-bed, or a baby being dropped to the floor by an adult, falling downstairs, from a bicycle, from horseback, from swings and slides or similar playing equipment and the child being hit by a bicycle.

Severe: Falling from a height exceeding 3 metres which includes most falls from windows or roofs. All traffic accidents - excluding cycling accidents - or being hit by a moving, heavy object.

In some injuries the degree of energy in the causative trauma was impossible to evaluate - these were birth injuries, being caught in doors or involvement with various types of household equipment.

A detailed breakdown of the classification is shown in Table A:II.

Registration errors

Out of those cases registered as fractures in the Department of Diagnostic Radiology only 6 (0.7 pro mille) could not be retrieved and were, therefore, considered to have been miscoded or misfiled. Although the reverse, fractures not filed, cannot be examined, it must be concluded that coding and filing errors should not be considered in the further analysis of the data. This survey, it appears, is actually dealing with almost all fractures in children below 17 that were diagnosed by a roentgen examination during the period covered by the study.

Statistical methods

For the purpose of calculating the current incidence of various types of fracture in children, all fractures recorded because of a roentgen diagnosis during the 5 years from 1975 to 1979 were included: a total of 4,621 fractures in 4,115 individuals. The age distribution was represented as one 3-year group - 0-2 - thereafter 2-year groups.

For the purpose of studying possible trends of change, fractures recorded during the years 1950, 1955, 1960, 1965 and 1970 - 4,061 fractures in 3,846 individuals - were added, providing for the trend study a total of 8,682 fractures. For statistical analysis the data has also been subdivided into "the first two decades" (1950, 1955, 1960, 1965) and "the last decade" (1970, 1975, 1976, 1977, 1978, 1979).

For data coding and processing, a Hewlett Packard 9845B desk top computer equipped with HP 9895A flexible disk memory and the NMSP* statistical analysis package was used.

For the studies of differences between incidences the Chi-square and Poisson analyses were used.

* *New Mathematical Statistics Package. Tore Persson, Institute of Mathematical Statistics, University of Lund.*

RESULTS: General

Age and sex specific incidence

The risk of fracture increased in children of both sexes up to the age of 11-12 years and then decreased in girls but further increased in boys (Figure 3). Fractures were more common among boys in all age groups, and after 11-12 they became twice as common as in girls ($p < 0.001$). The overall annual incidence in boys was 257, in girls 165 and in both sexes 212 per 10,000.

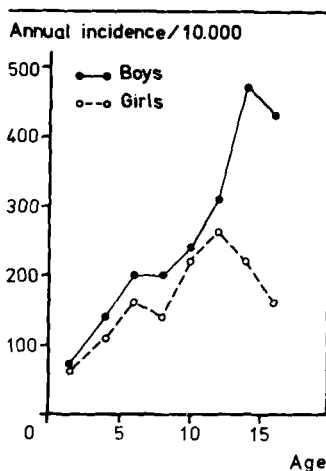


Figure 3. Age and sex specific incidence - all fractures.

The accumulated risk of having at least one fracture from birth to the age of 16 was 4,201 per 10,000 (42 per cent) in boys and 2,727 per 10,000 (27 per cent) in girls.

In all, 62 per cent of the fractures occurred in boys and there was no significant change in this sex difference throughout the decades studied (Figure 4).

Comment: The predominance of boys is a common finding in recent as well as earlier investigations of fractures in children (Bruns 1886, Hanlon & Estes 1954, Lichtenberg 1954, Pellerin et al. 1971, Iqbal 1974, Reed 1977, Sano & Kitamura 1979).

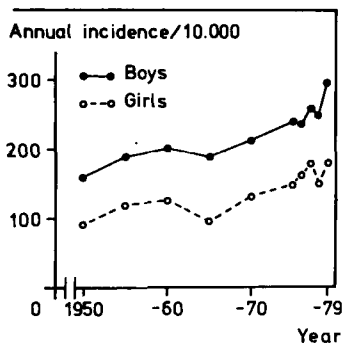


Figure 4. Incidence of fracture in relation to time over three decades.

In the age specific incidence of all types of childhood accidents, also other than fractures, there is a peak about age 2 and usually another at the age of 11-14. There seems to be no deviation from this pattern in reports from Scandinavian countries (Hindmarsh et al. 1946, Berfenstam et al. 1957, Kølle-Jørgensen 1971, Gustafsson 1975, Nathorst Westfelt 1982).

Secular trend

The risk of fracture in the city increased during the 30 years covered by this study in boys as well as in girls ($p < 0.001$) (Figure 4). Comparing the last decade with the first two decades, increase in fracture rate in the 70's was most obvious in the older children, particularly in the boys (Figure 5). The risk of fracture had - all age groups included - been almost doubled.

Severity of trauma

During the period 1975-1979, the fractures were caused by trauma classified as slight in 66 per cent, moderate in 19 per cent, severe in 7 per cent and not classified or unknown in 8 per cent. This pattern had changed over the years: during the 30-year-observation period, the annual incidence of fractures caused by slight trauma increased three times ($p < 0.001$). The more severe types of trauma increased only slightly, although significantly, over the years ($p < 0.001$) (Figure 6). The increase in the risk of

fracture caused by slight trauma was significant in both sexes and the increase during the last decade was greater in boys. All types of trauma were more frequent in boys than in girls, also in cases of severe trauma the boys were predominant ($p < 0.001$). However, the more severe types of trauma did not change much over the 30-year-period under study (Figure 7).

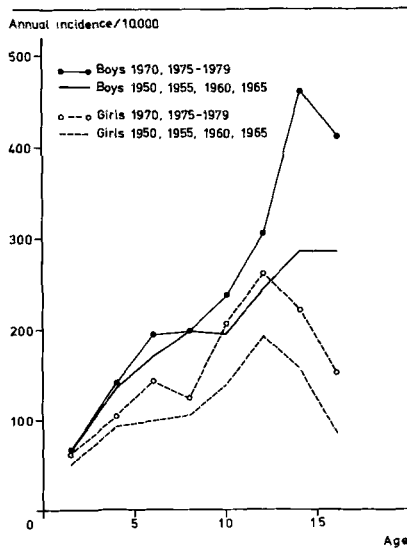


Figure 5. Incidence change - the last decade compared with the first two - boys and girls, separately.

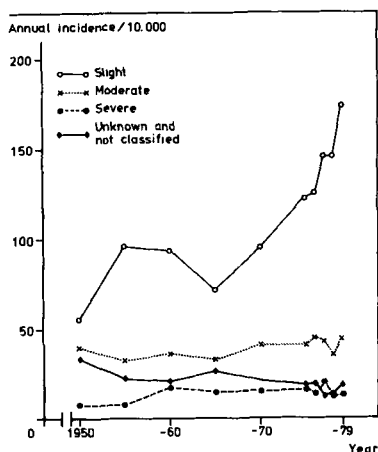


Figure 6. Trauma severity in relation to time.

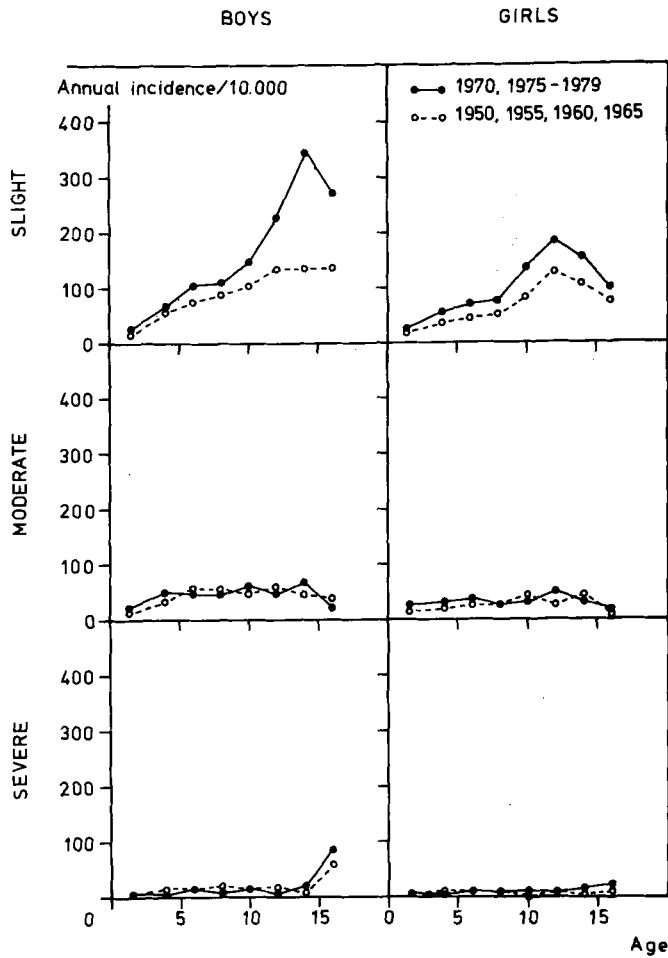


Figure 7. Trauma severity in relation to time, sex and age.

Frequency of fracture types.

The most common fracture in children was fracture of the distal end of the forearm which contributed almost 1/4 of all fractures followed by fractures of the hand phalanges and of the carpal and metacarpal region. The ten most common types of fracture, the least common of these being the supracondylar fracture of the

humerus, contributed 83 per cent to the total number. Eighty-nine per cent of the fractures were considered to be represented in a sufficient number for calculation of the age and sex specific incidence, the least common of these being femur shaft fractures, 75 fractures (Table 1).

Table 1. The frequency of various fracture types.

	Per cent
Distal forearm	22.7
Hand, phalanges	18.9
Carpal-metacarpal (scaphoid excluded)	8.3
Clavicle	8.1
Ankle	5.5
Tibia, diaphysis	5.0
Tarsal-metatarsal (talus, os calcis excluded)	4.5
Foot, phalanges	3.4
Radius-ulna, diaphysis	3.4
Supracondylar region of the humerus	3.3
Proximal end of the humerus	2.2
Facial skeleton	2.1
Skull	1.8
Femur shaft	1.6
Radial neck fracture	1.2
Vertebral fracture	1.2

Comment: The frequency of the various types of fracture in children is by and large the same, comparing investigations from different parts of the world such as USA (Lichtenberg 1954), England (Buhr & Cooke 1959), East Germany (Panzner 1966), Czechoslovakia (Engler 1967), Australia (Lopez & Rennie 1969), Denmark (Kølle-Jørgensen 1971) and Malaysia (Iqbal 1974). However, there are some noteworthy exemptions from this general pattern:

In the large Austrian survey of more than a quarter of a million childhood accidents (Jonasch & Bertel 1981) 62,000 were bone

injuries and the most frequently affected bone was the tibia, contributing 13 per cent. The most common single cause of fracture, all types included, was skiing in 20 per cent and skiing was also the dominant factor in the production of tibial fractures - 70 per cent. The French investigation by Pellerin et al. (1971) revealed an unusually high number of fractures of the humerus diaphysis, this localization being more frequent than fractures of the proximal end of the humerus and of the supra-condylar region as well. However, their data was collected in a centre for pediatric surgery with severe trauma cases referred from other hospitals.

The data collection procedure probably also influences the number of fractures in other reports which could to some extent explain for instance the high frequency of skull fractures in the study by Reed (1977) from Winnipeg, Canada, in a hospital to which all severe injuries were referred. Therefore, one may conclude that the fracture pattern in children is virtually the same in various parts of the world and that differences in frequencies may be explained by external factors and variations in registration procedures rather than genetic factors. This is in contrast to old age injuries, for example hip fractures, where ethnic factors play a role (Moldawer et al. 1965, Wong 1966).

Activity and environmental factors

In 34 per cent of the fractures there was no known relationship to any specific activity or environment. Playing, sports and traffic contributed 24, 21 and 12 per cent, respectively. The details of this and the fractures typical of the various activities are presented in Tables 2 and 3. More than 90 per cent of the fractures sustained during fighting were localized to the hand and the facial skeleton. Forty per cent of the fractures sustained during skiing were fractures of the tibial shaft and nearly 1/4 of the fractures associated with horse-riding were fractures of the proximal end of the humerus.

Table 2. The contribution of various environmental factors and activities to the total number of fractures 1975 - 1979.

	Per cent
<u>Home</u>	5
<u>Nursing home, day-care centre</u>	1
<u>School, school yard</u>	4
<u>Traffic accidents</u>	12
Bicycle	6
Pedestrian hit by vehicle	2
Moped, motorcycle (driver or passenger)	2
Car passenger	1
Spoke injury	1
<u>Playing accidents</u>	24
Playground	9
Scuffles	3
Tricycles, pedal cars, sleighs	2
Skateboard, roller skates	2
Other	8
<u>Sport accidents</u>	21
Ball sports	10
Ice-hockey, skating	3
Equestrian sports	3
Skiing	2
Wrestling, boxing, karate et cetera	2
Gymnastics	1
No known relationship with any specific activity or environmental factor	34

Table 3. The three most common fracture types for various types of activities.
Per cent within each group.

<u>Sleights, pedal cars, tricycles</u>		<u>Skateboard, roller skates</u>	
Distal forearm	21%	Distal forearm	66%
Tibia, diaphysis	17%	Ankle	13%
Femur shaft,		Hand, phalanges	11%
hand phalanges, each	8%		
<u>Fights</u>		<u>Bicycle accidents</u>	
Carpal-metacarpal	71%	Distal forearm	27%
Facial skeleton	11%	Hand, phalanges	13%
Hand, phalanges	9%	Clavicle	11%
<u>Pedestrian hit by vehicle</u>		<u>Moped, motorcycle</u>	
Tibia, diaphysis	26%	Distal forearm	17%
Clavicle	12%	Tibia, diaphysis	13%
Pelvis	7%	Ankle	11%
<u>Ball sports</u>		<u>Skiing</u>	
Hand, phalanges	49%	Tibia, diaphysis	40%
Distal forearm	18%	Hand, phalanges	17%
Ankle	6%	Ankle	10%
<u>Ice-hockey, skating</u>		<u>Horse-riding</u>	
Distal forearm	50%	Proximal end of humerus	28%
Carpal-metacarpal	11%	Distal forearm	22%
Clavicle	9%	Clavicle	9%

Traffic accidents causing fractures (Figure 8) increased over the 30 years by 1/3 in boys ($p < 0.01$). Girls, who over the years maintained a risk of traffic fractures of less than half of that of the boys, nevertheless increased their risk by approximately the same rate ($p < 0.001$). In both sexes the increase in the risk of traffic accidents was in the older age groups, the young pre-school children did not increase their risk.

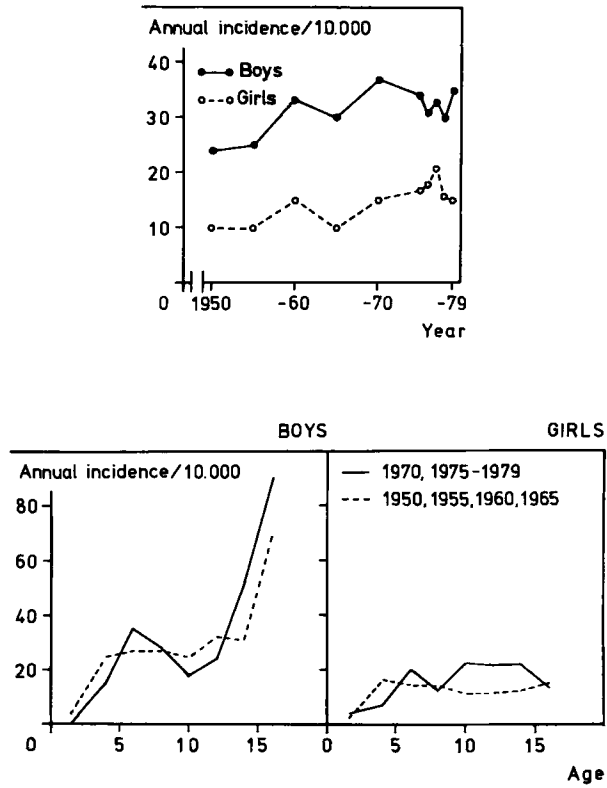


Figure 8. Traffic accidents, incidence in relation to time, age and sex.

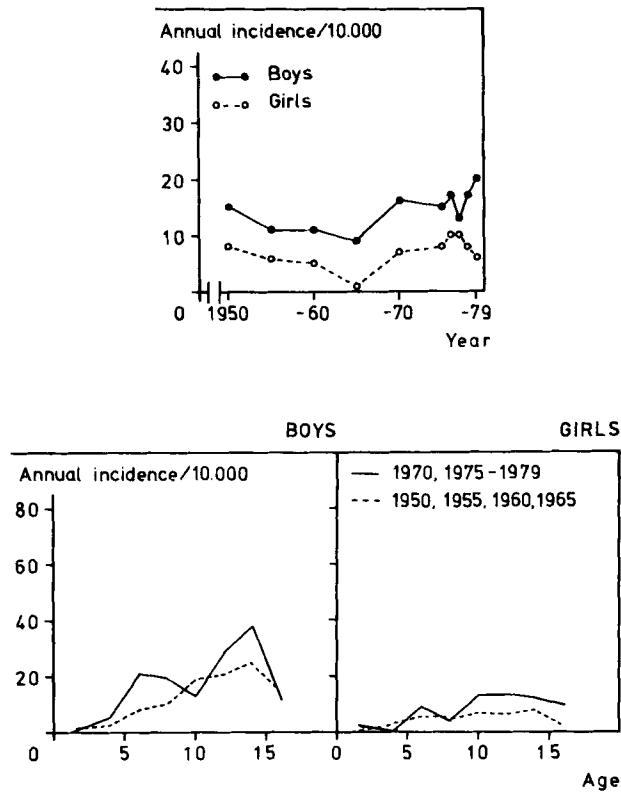


Figure 9. Bicycle accidents, incidence in relation to time, age and sex.

Bicycle accidents (Figure 9), in particular, changed irregularly over the years but with an increasing tendency ($p < 0.001$). Throughout the period under observation bicycle accidents were more frequent in boys ($p < 0.001$). During the more recent part of the period a bimodal age distribution was found with an early and a late maximum.

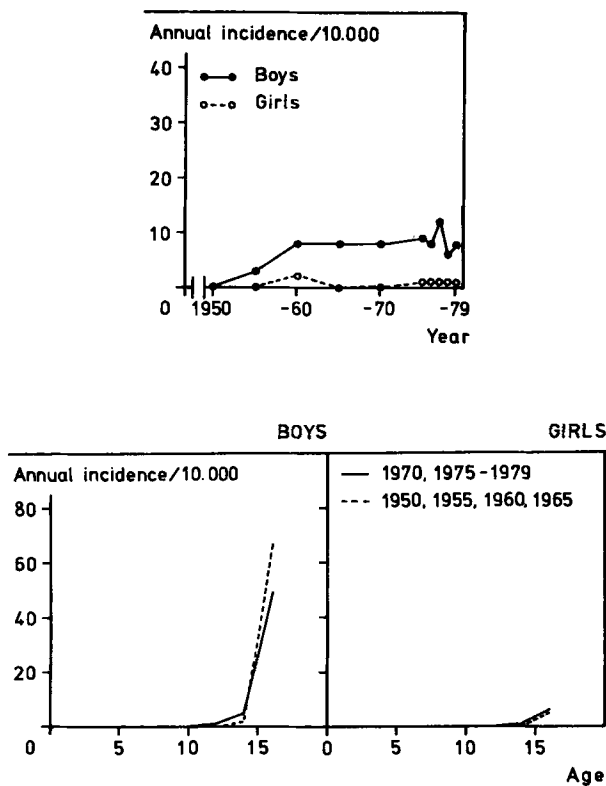


Figure 10. Moped and motorcycle injuries, incidence in relation to time, age and sex.

Moped and motorcycle injuries (Figure 10) were observed only in the 15-16-year-olds except in a few cases of illegal driving by younger children. The incidence increased by a factor of 6 during the first 10 years under observation, which coincided with the introduction of the moped and has since then remained fairly constant but with a tendency of dropping off more recently in boys (n.s.).

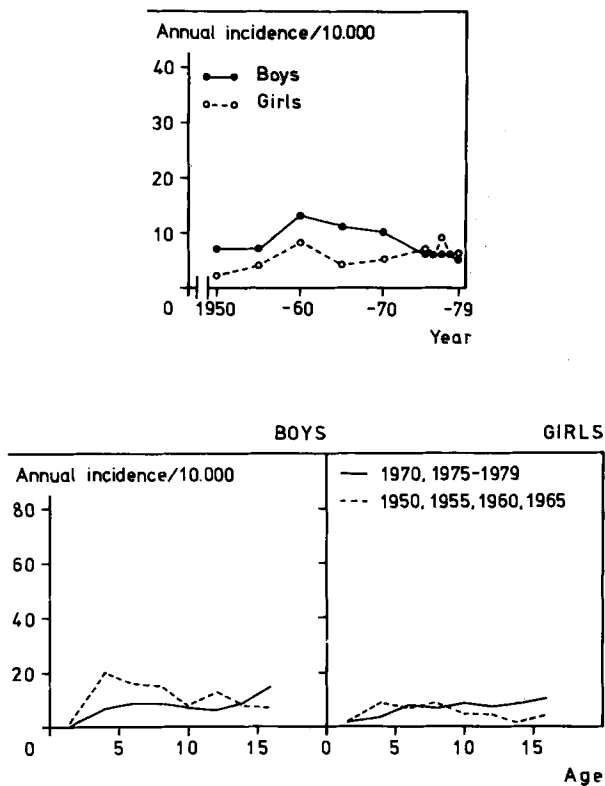


Figure 11. Fractures sustained by passive traffic participants, incidence in relation to time, age and sex.

The passive participants in traffic accidents - pedestrians and passengers in various motor vehicles (excluding mopeds and motorcycles) - changed but little over the years (Figure 11). There was, however, a decreasing tendency in boys ($p < 0.01$) and an increasing tendency in girls ($p < 0.05$) so that there appears to be no difference between the sexes in this respect in recent years. Comparison within age groups revealed that little boys are doing better (0-8 years, $p < 0.01$) with regard to traffic fractures today than in the 1950's and 1960's whereas older girls - 9 to 16 - are doing worse ($p < 0.001$).

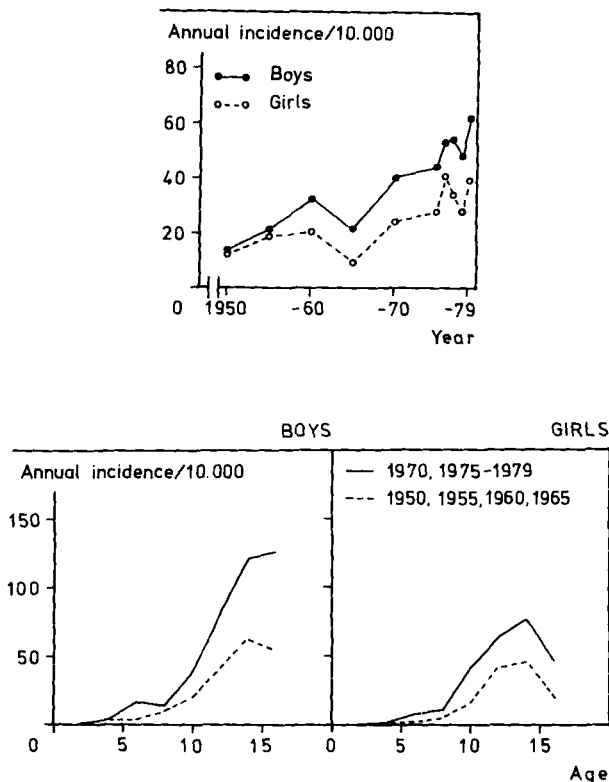


Figure 12. Sport accidents, incidence in relation to time, age and sex.

Fractures due to sport accidents (Figure 12), recently 21 per cent of the fractures, have increased by a factor of approximately 5 during the 30 years. The change was more pronounced in the older age groups and more obvious in boys than in girls. The risk of sport injuries in girls was approximately half of that in boys ($p < 0.001$) with a decreasing tendency in the oldest age groups. Out of the various types of sport, four were analysed separately: ball games (soccer, handball, volleyball, basketball, Figure 13), skiing (down-hill and cross-country, Figure 14), ice-skating including ice-hockey (Figure 15) and equestrian sports (Figure 16).

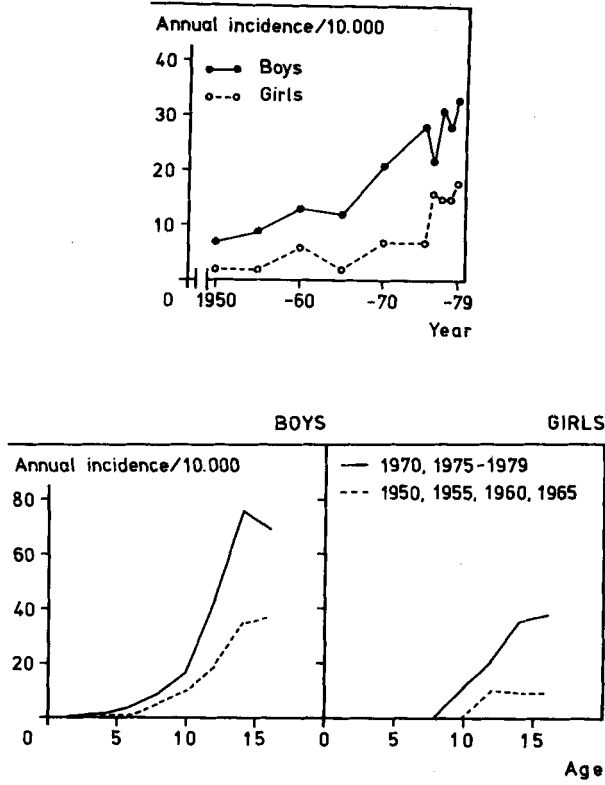


Figure 13. Ball game accidents, incidence in relation to time, age and sex.

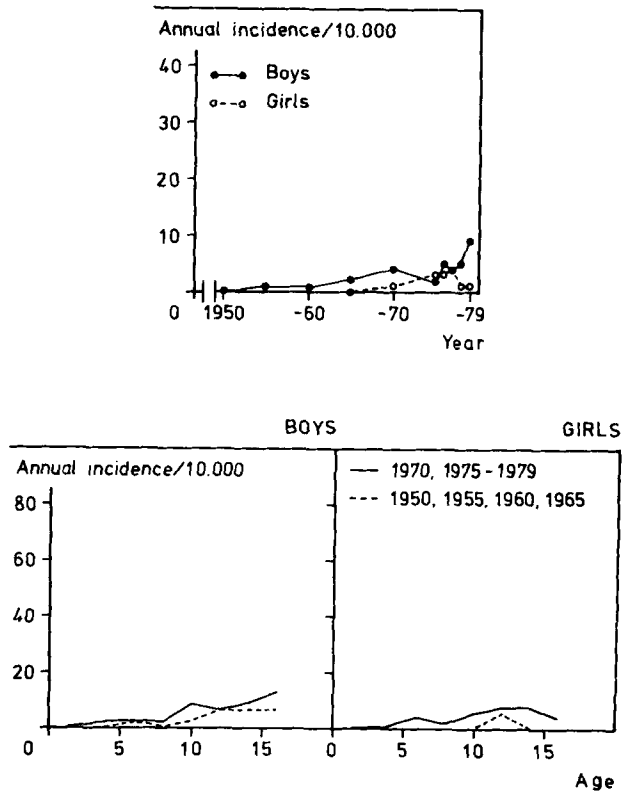


Figure 14. Skiing accidents, incidence in relation to time, age and sex.

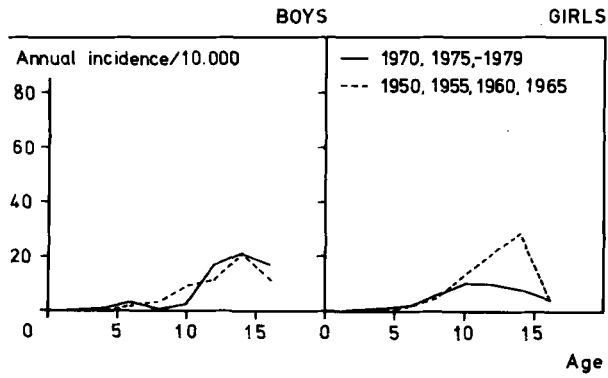
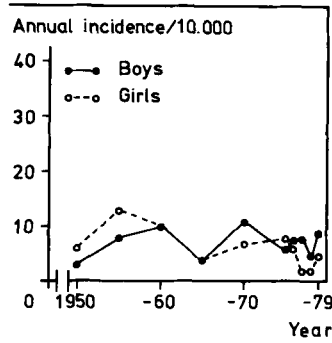


Figure 15. Skating accidents, incidence in relation to time, age and sex.

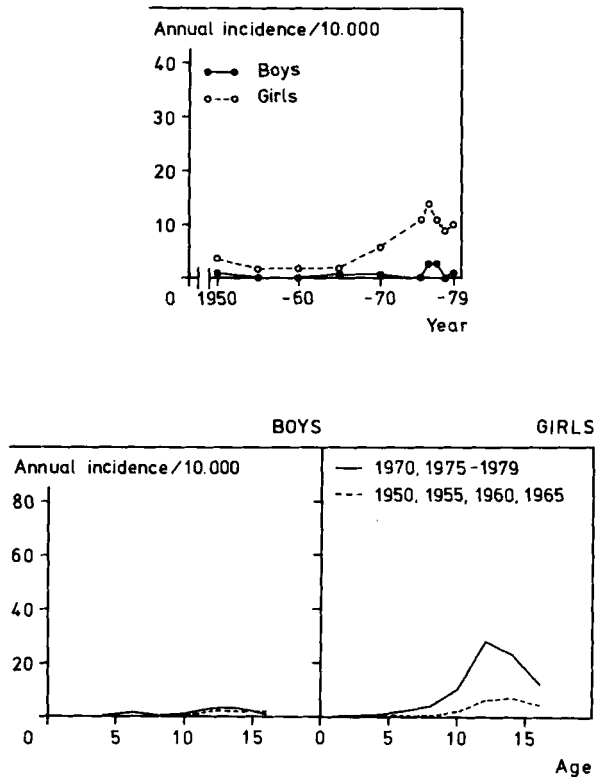


Figure 16. Equestrian sports accidents, incidence in relation to time, age and sex.

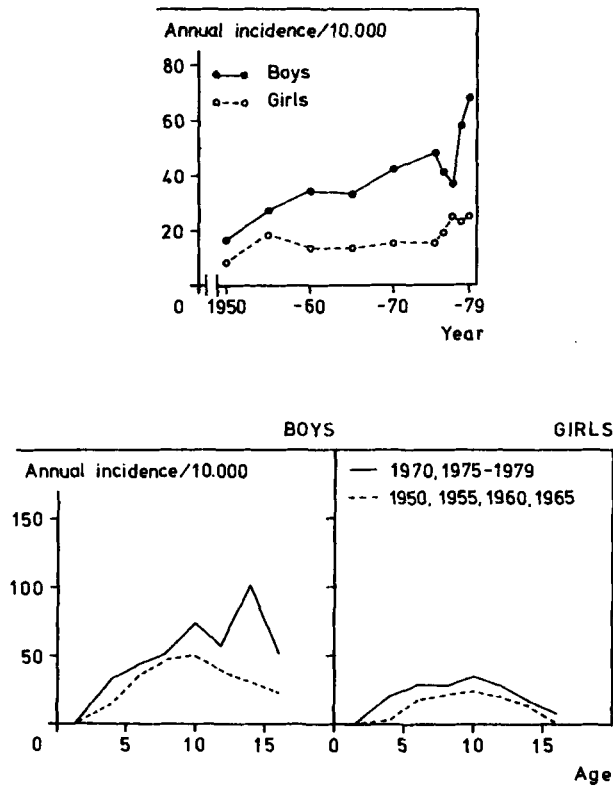


Figure 17. Playing accidents, incidence in relation to time, age and sex.

Playing (Figure 17) involves a variety of activities; in this study four were selected for analysis: scuffles among children (Figure 18), skateboard and roller-skating injuries (Figure 19), injuries caused by fixtures and equipment in playgrounds (Figure 20) and injuries in which toys or equipment such as tricycles, pedal-cars, sleighs et cetera were involved (Figure 21).

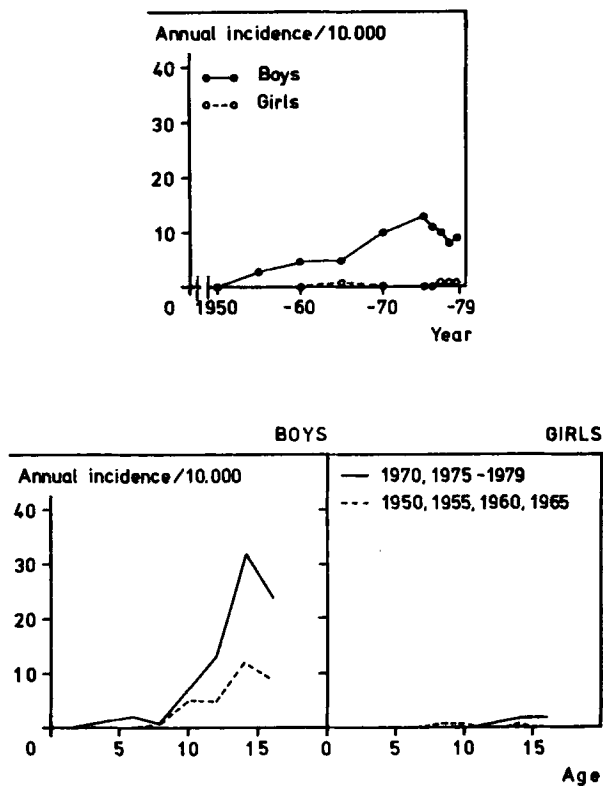


Figure 18. Scuffle accidents, incidence in relation to time, age and sex.

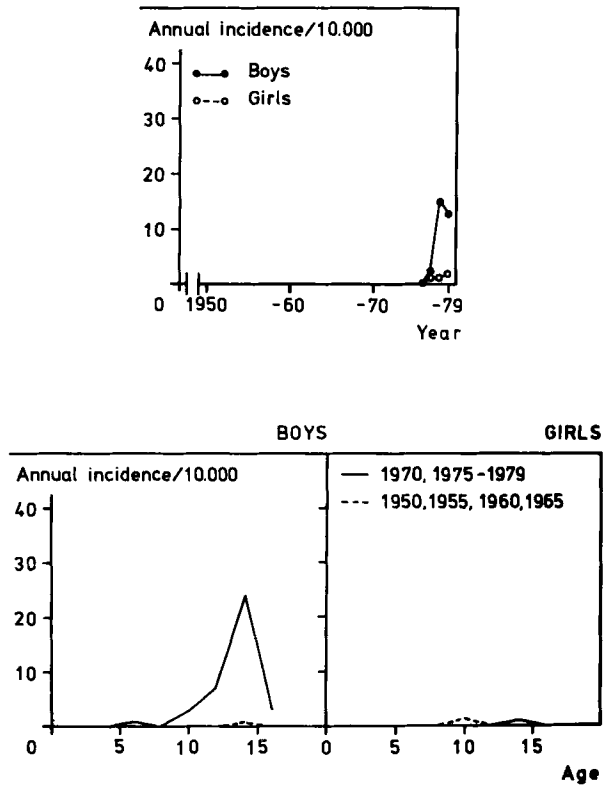


Figure 19. Skateboard and roller skate accidents, incidence in relation to time, age and sex.

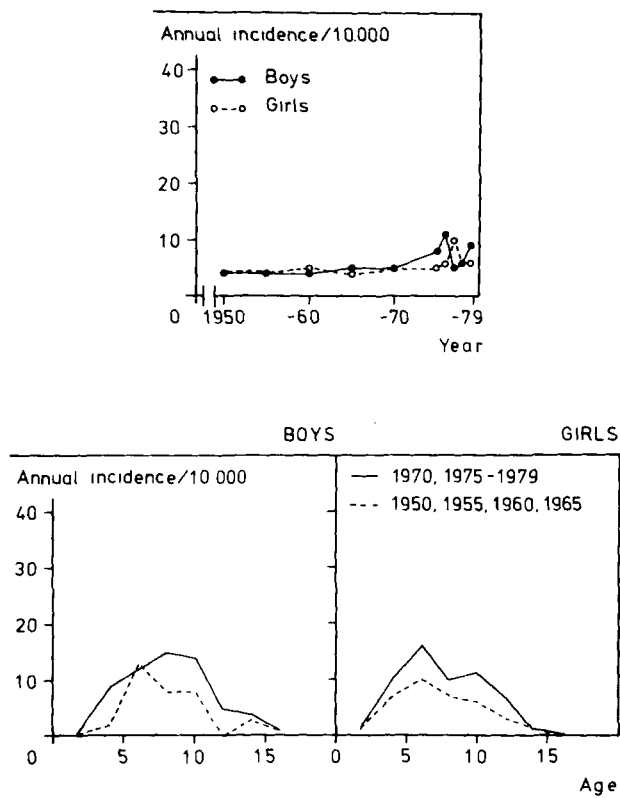


Figure 20. Playground equipment accidents, incidence in relation to time, age and sex.

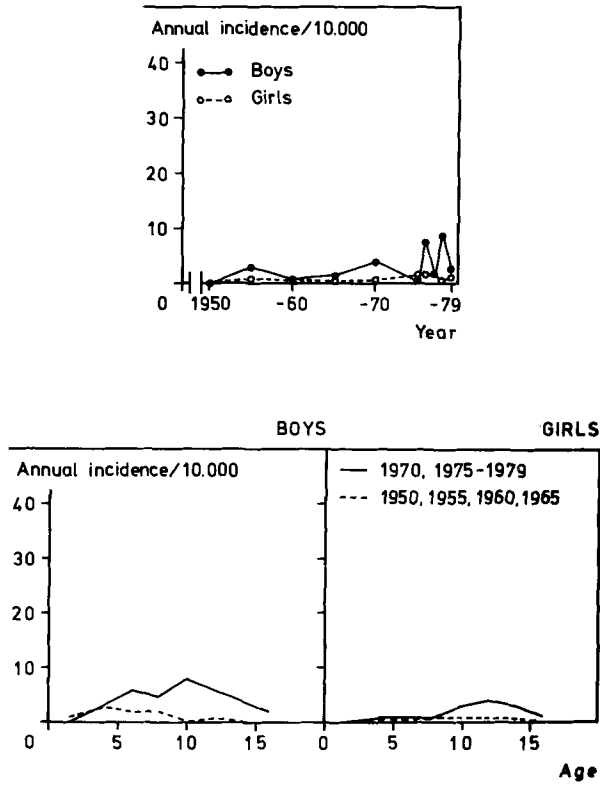


Figure 21. Toy accidents, incidence in relation to time, age and sex.

Comment: The ball games contribute most to sport fractures; in older boys, ball games only contribute today as many fractures as traffic. Also, in girls, however, there has been a striking increase in the number of fractures caused by ball games ($p < 0.001$). Skating injuries, including ice-hockey have changed very little over the years - although the incidence drop in girls was significant ($p < 0.001$) - in spite of an increase in the facilities and interest for these sports. Sustaining a skiing fracture in an area without hills and usually also without snow should be almost impossible - the slowly increasing risk of skiing injuries ($p < 0.001$) mostly reflects the growing number of children travelling to ski resort areas. Horseback riding and riding accidents causing fracture are, in the city, almost entirely a female affair and appear to be limited to approximately a period of 5 years in the lives of these girls - the increase was significant ($p < 0.001$).

In playing injuries, contributing about 24 per cent of all fractures in children, a highly significant increase was seen - about 5 times over the 30 years. The increase was significant only in boys ($p < 0.001$), particularly in the older boys. In the oldest girls playing injuries were rare.

Special activities were analysed with regard to their contribution to the playing injuries: Fractures caused when using playground fixtures (swings, slides etc.) increased somewhat in recent years ($p < 0.05$), the victims being usually the younger children. Fractures caused by various privately owned playing equipment such as sleighs, pedal cars and tricycles have also increased somewhat in boys ($p < 0.001$) as well as in girls ($p < 0.05$). Fights among children have lately become a more common cause of fracture, particularly in the young teen-age boys. In the later years of the period under observation there was a break-through for the skateboards and roller skates which also left their contribution to the fracture pattern in the older boys. In fact these three factors - injuries caused by the various types of playing equipment, fighting and the roller skate and skateboard crazes - account for most of the increase observed in playing injuries.

Side preponderance

There was a significant preponderance for left-sided fractures with a left/right ratio of 1.3/1 ($p < 0.001$). Most fractures, however, had no significant side preponderance, the exceptions to this rule are listed in Table 4.

Table 4. Side preponderance for some fractures of the appendicular skeleton.

	Left/Right ratio	
Supracondylar fracture of the humerus	1.5/1	$p < 0.05$
Fracture of the lateral humerus condyle	2.3/1	$p < 0.05$
Distal forearm	1.5/1	$p < 0.01$
Carpal-metacarpal	0.5/1	$p < 0.01$
Ankle fractures	0.8/1	$p < 0.05$

Comment: Left-side preponderance for fractures in childhood has also been observed in Pennsylvania, USA (Hanlon & Estes 1954), Malaysia (Iqbal 1974) and Canada (Reed 1977).

Fractures in the upper extremity are in the majority of cases affecting the left side, possibly because the right arm is otherwise occupied. Holmberg (1945) and Henrikson (1966) have reported supracondylar fractures of the humerus to be more common on the left side. Contrary to the upper extremity, fractures of the ankle were significantly more often observed on the right side. However, Vahvanen & Aalto (1980) in an investigation of 310 ankle fractures in children found a left/right ratio of 1.4/1.

Seasonal variation

The occurrence of fractures varied with the seasons with peak values in May, low values during June and July and, again, a high risk in the autumn which dropped off to become low again in December (Figure 22). This fluctuation was highly significant ($p < 0.001$). When the seasonal variation was studied including all fractures, also those collected for secular trend studies, the pattern remained unchanged, and the same was found when only the first two decades were studied. Even if only fractures that had been treated with reduction were included the pattern

remained unchanged. The seasonal variation of physeal fractures was the same as for the whole material (Figure 23).

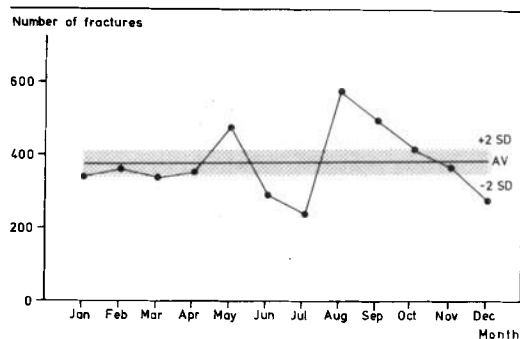


Figure 22. Seasonal variation (fractures 1975 - 1979).

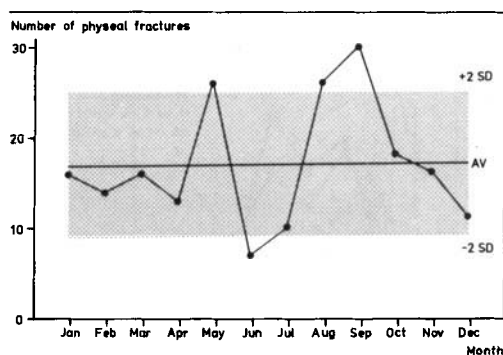


Figure 23. Seasonal variation of physeal fractures (1975 - 1979).

Comment: This pattern of seasonal variation is a constant finding in Scandinavian surveys of childhood accidents also including injuries other than fractures and is usually assumed to be an effect of summer holidays when a considerable part of the urban child population is leaving the city for vacation (Berfenstam et

al. 1957, Kølbe-Jørgensen 1971, Gustafsson 1975, Nathorst Westfelt 1982). In the Göteborg study by Nathorst Westfelt (1982) the frequency of accidents in July was the same as the frequency recorded in June and August when 400 missing cases treated in hospitals outside Göteborg were added to the observed number. Hindmarsh et al. (1946), in a report of child accidents from a rural area in Sweden in the 1930's found that child accidents were more common in summer. However, fractures requiring reduction in the present study would, most likely, have returned for roentgen controls in the city - nevertheless such fractures also varied with the seasons. Epiphyseolysis of the femoral head is more frequent in summer, possibly because of a weakening of the growth plate (Andrén & Borgström 1958). However, trauma-related physal fractures follow closely the pattern of other fractures.

Month of birth and risk of fracture

The seasonal variation of births during 1975 - 1979 and the month of birth of the children with fractures caused by slight trauma are illustrated in Figure 24.

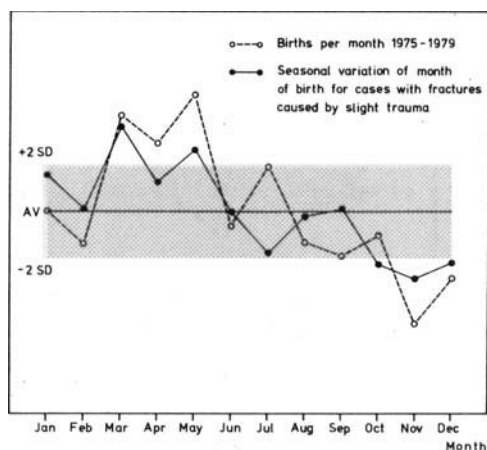


Figure 24. Seasonal variation of births in Malmö compared with the variation observed in children with fractures caused by slight trauma.

Comment: In an investigation of hip fractures in the elderly, Alffram (1964) found that the risk of sustaining a hip fracture in old age was significantly higher among persons born in the autumn. This finding suggests a seasonal postnatal effect on the skeleton persisting in old age. If this effect still exists it does not interfere with the fracture risk in children.

Birth fractures

In the study altogether 38 fractures were encountered, which had occurred in immediate conjunction with birth. The annual number of births in the city varied between 2,400 and 4,000 over the years. The observed incidence of birth fractures calculated per 10,000 live births is demonstrated in Figure 25 and the various types of fractures in Table 5. The number of roentgen-diagnosed birth fractures suggests an increasing risk over the years, the incidence being 5 times higher at the end of the 1970's as compared with 1950.

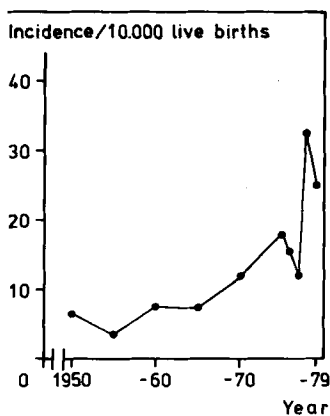


Figure 25. Incidence of birth fractures .

Table 5. Birth fractures.

Fracture type	Number
Clavicle	27
Humerus, diaphysis	6
Skull	4
Forearm, diaphysis	1

Comment: The changes in delivery techniques over the last decades with increasing use of Caesarian section and decreasing use of forceps should lower the risk of birth fractures. However, in the early part of the period under investigation, fracture of the clavicle, as an example, was probably regarded as a normal event which did not warrant roentgen examination. Farkas & Levine (1950) examined 300 consecutive, living term babies, who were delivered by vertex presentation, with roentgen for fracture of the clavicle. Five clavicle fractures were discovered, 1.7 per cent, none of which had even been suspected in the postpartem and subsequent pediatric examinations. Thus, the incidence encountered by Farkas & Levine (1950) considering only fracture of the clavicle was far beyond the total incidence in this series. Therefore, the present data might simply reflect an increasing tendency of roentgen-examination of the new-born.

Fragility fractures

In old age certain fractures such as hip fracture, vertebral compression fracture, fracture of the distal end of the forearm and the proximal end of the humerus are believed to be due to bone fragility and are also associated with a below average bone mineral content (Vose & Lockwood 1965, Nilsson & Westlin 1977).

In order to investigate whether any of the fractures in children could meet the criteria of a fragility fracture the percentage of the three degrees of trauma severity was calculated for each fracture (Table 6). Also, the various fractures were ranked within the groups of trauma severity (Table 7). Fractures of the carpal-metacarpal region, hand and foot phalanges, ankle and distal forearm were to a greater extent produced by low energy trauma than the others. The most frequently fractured region for

all degrees of trauma severity was, however, the distal end of the forearm. Fractures of the skull and the femur were more often produced by higher energy levels. In the upper extremity fractures of the clavicle, the proximal end of the humerus and the supracondylar region of the humerus were comparatively more often caused by higher energy levels than fractures of the distal forearm, falls still being the most common cause in all instances.

Table 6. The distribution of the different degrees of trauma severity within the various types of fracture. The data did not permit evaluation of the degree of trauma in all cases.

	Per cent		
	Slight	Moderate	Severe
Skull	31	45	19
Proximal end of the humerus	46	45	5
Clavicle	61	25	5
Supracondylar region of the humerus	57	37	1
Radius-ulna, diaphysis	62	26	3
Distal forearm	71	22	4
Carpal-metacarpal	81	9	4
Hand, phalanges	75	7	2
Femur, diaphysis	52	16	25
Tibia, diaphysis	53	19	19
Ankle	72	16	8
Tarsal-metatarsal	58	34	6
Foot, phalanges	73	8	11

Table 7. The three most common types of fracture for each degree of trauma severity.

<u>Slight</u>	<u>Moderate</u>	<u>Severe</u>
Distal forearm	Distal forearm	Distal forearm
Hand, phalanges	Clavicle	Tibia, diaphysis
Carpal-metacarpal	Tarsal-metatarsal	Clavicle

Also, the distribution between various fracture types was the same in children with more than one fracture as overall even when only low energy trauma was included.

Fracture repeaters

In 1975, 869 children presented with fracture. In this study these same children could be observed for an additional 2,760 child-risk years. During this observation period 107 of the 869 had at least one more fracture, significantly more than expected in the population at risk ($p < 0.01$). In Table 8 the overall fracture risk in children in the city, is compared with the risk of children who already have had a fracture. The deviation in the risk of having an additional fracture was greatest in the very young children. Also, boys were more often repeaters than girls, if all children who were registered because of a fracture in 1979 were reviewed for fractures earlier in life ($p < 0.05$) (Figure 26).

Table 8. Incidence of another fracture in children with one fracture compared with the overall incidence.

Age group	Annual fracture incidence per 10,000		Relative risk	p-value
	Overall	≥ 1 previous fracture		
1 - 2	82	270	3.3	n.s.
3 - 4	124	467	3.8	$p < 0.001$
5 - 6	179	386	2.2	$p < 0.05$
7 - 8	170	141	0.8	n.s.
9 - 10	211	345	1.6	n.s.
11 - 12	284	348	1.2	n.s.
13 - 14	351	545	1.6	$p < 0.05$
15 - 16	297	314	1.1	n.s.

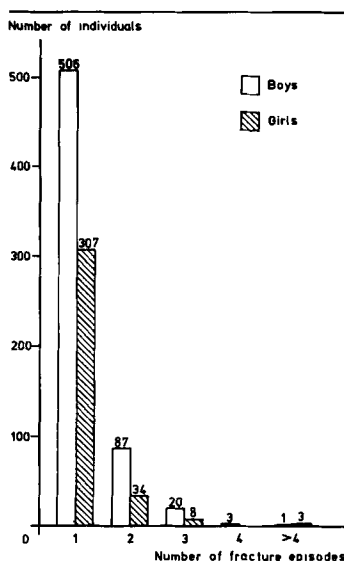


Figure 26. Number of fracture episodes in children with fracture in 1979.

Minor fractures

It has been of special interest to study those minor fractures which could most easily escape diagnosis, particularly during the first part of this study. These should be the fractures with a limited period of pain and discomfort for the child. Some of these fractures have, no doubt, increased more than average over the period under observation. The three fractures most likely to remain undetected would probably be: avulsion fractures, including only a small fragment regardless of localization, unreduced fractures of the distal forearm and unreduced fractures of the phalanges of the hand. In Figure 27 the total incidence of such fractures in children is presented in relation to time and overall fracture incidence. When these fractures were subtracted from the total the increasing trend was less pronounced but still significant ($p < 0.001$). However, the changes with time in such minor fractures may be inconsistent. In the most common avulsion fractures, for example avulsions in the area of the ankle and the

hand, there was a difference; the hand injuries had increased with time but not the ankle injuries (Figure 28).

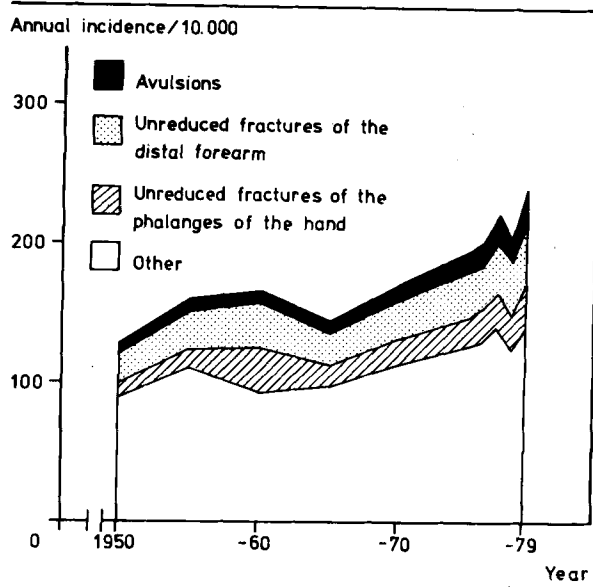


Figure 27. The overall fracture incidence with the distribution of minor fractures indicated.

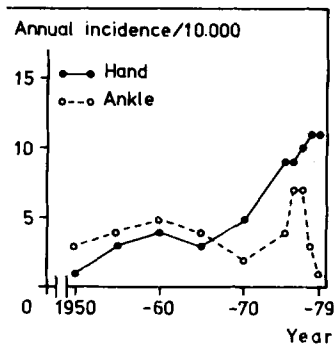


Figure 28. Avulsion fractures of the hand and ankle in relation to time.

Treatment trends

Although the incidence and the number of fractures had increased over the last three decades, the number requiring reduction had remained fairly constant over the years. There are no objective reasons to believe that the attitude towards treatment has changed but rather that the fractures not requiring reduction, open or closed, have increased the most (Figure 29).

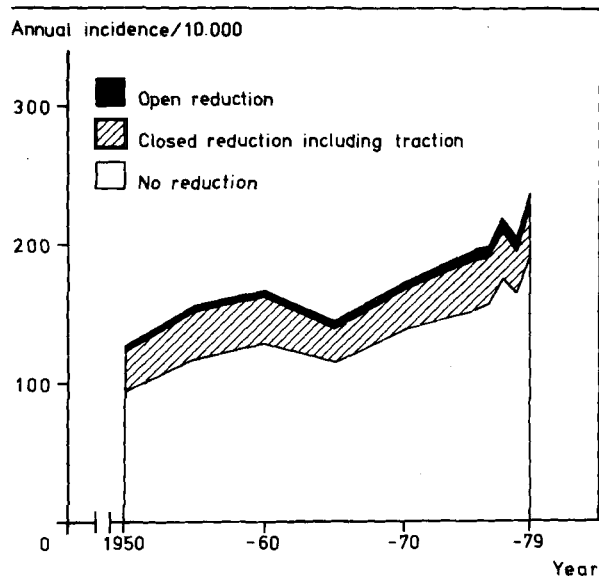


Figure 29. Treatment trends.

Concomitant disease

Various diseases in childhood have been shown to be associated with a bone mineral content below the average: renal disease (Chesney et al. 1977), cystic fibrosis (Mischler et al. 1979), diabetes mellitus (Shore et al. 1981), growth hormone deficiency (Shore et al. 1980), Turner's syndrome (Shore et al. 1983) and anticonvulsant-induced osteomalacia (Barden et al. 1983).

Some childhood disorders and diseases which hypothetically could carry an increased risk of fracture are listed in Table 9.

e 9. The number of fractures sustained by children with various disorders. The ratio of slight trauma/moderate + severe trauma. The degree of trauma could not be determined in all cases.

Order	No. of fractures/ No. of individuals	Slight trauma/moderate + severe trauma
Osteogenesis imperfecta	13/2	6/2
"Biological" fractures	7/7	6/1
Neurological disorder such as cerebral palsy, epilepsy, hereditary atrophy, myelomeningocele.	22/15	9/4
Psoriatic arthritis	8/5	8/0
Mental retardation	16/13	9/5
Diabetes mellitus	3/2	1/1
Idiopathic osteodystrophy	3/2	3/0
Endocrine disease	3/2	3/0
Malabsorption	1/1	0/1
Craniofacial malformation Dysostosis	10/7	8/0
Leukemias (e.g. leukemia, radiation treatment)	8/7	5/1
Total	94/63	58/15

Comment: Fractures in the elderly such as hip fractures (Alffram 1974) and fractures of the proximal end of the humerus (Horak & Sorenson 1975) often coincide with other diseases. The low number of fractures sustained by individuals with concomitant disease in this series merely reflects the scarcity of these conditions and indicates that this child population was on the whole free from disorders with an increased risk of fracture.

In the whole series in 1975 - 1979, 4,621 fractures were observed in 4,115 individuals. In the conditions listed, 94 fractures were sustained by 63 individuals which is a higher number of fractures than expected as compared with the rest of the fracture population without any known concomitant disorder ($p < 0.05$).

In most of the conditions listed in Table 9 our knowledge of the prevalence is incomplete. For mental retardation and diabetes in

children - conditions in which the prevalence for the country and the city may be calculated with some confidence (Grunewald 1979, Dahlqvist et al. 1982) - the risk of fracture does not seem to be increased.

RESULTS: Epidemiology of specific fracture types

Of the 14 most common fracture types (locations) 13 were selected for incidence studies - fractures of the facial skeleton, being a heterogeneous group, were excluded. Altogether 89 per cent of the fractures encountered 1975 - 1979 were included for the purpose.

Fracture of the distal end of the forearm

Included in this group were all distal metaphyseal fractures of the radius, of the ulna and of the styloid processes. In fractures which were on the borderline to diaphyseal fractures, the point at which the cortex had attained a constant thickness was chosen as the limit.

This was the most common fracture in individuals below the age of 17 and contributed 21 per cent - including physeal injuries 23 per cent. The boy/girl ratio was 1.6/1. The risk was highest in age 9 - 10 in girls and 13 - 14 in boys and the difference in total risk was entirely due to the high risk in the older boys (Figure 30, Table A:III). After 14 the fracture was three times as frequent in boys as in girls ($p < 0.001$).

Almost half of the fractures were caused by falling without any specific environmental factor being recorded. Ball games, bicycle accidents, playground and skateboard accidents together contributed 25 per cent of the cases.

The traffic accidents, except those involving bicycles, were only occasionally observed as a cause of fracture. Fracture in this region was predominantly associated with low energy trauma, severe trauma contributed only 4 per cent of the cases.

Removing fractures caused by roller skates, skateboards, moped accidents, ball games, wrestling and skating, drastically reduced the sex difference. Only fractures due to horse accidents were more common in girls.

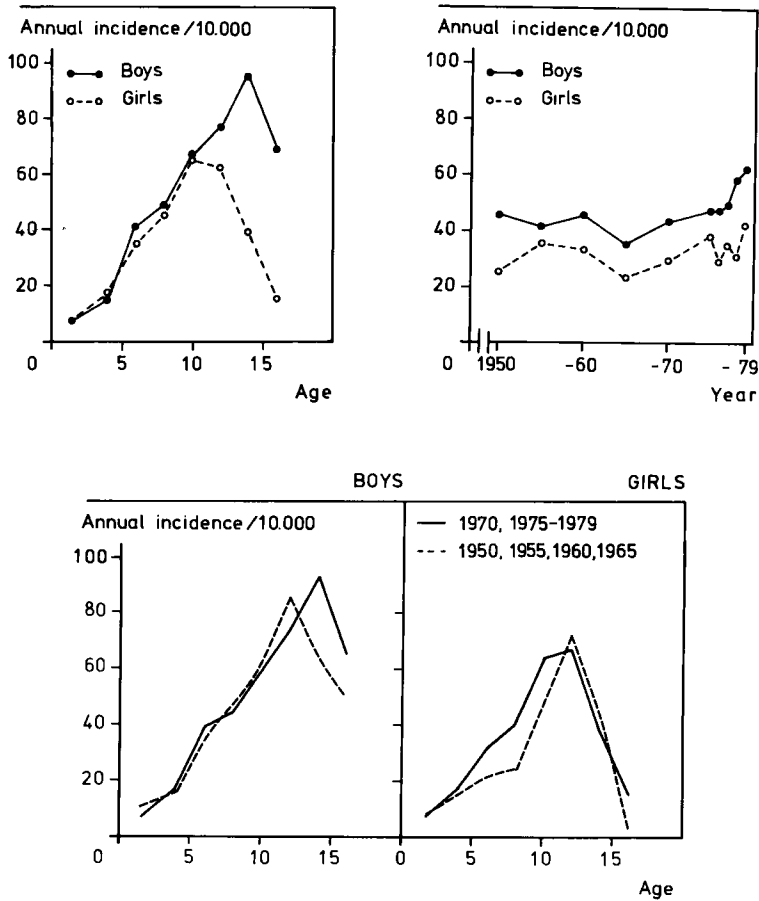


Figure 30. Distal forearm fractures, incidence in relation to age, sex and time.

The risk of fracture of the distal end of the forearm increased slightly but significantly over the years (Figure 30). The increase occurred in the older boys ($p < 0.001$) and in the younger girls ($p < 0.001$) and could be related to toys and other equipment.

Physeal fracture of the distal end of the radius was the single most common physeal injury, contributing more than half of this group. The incidence peak values coincide with those of the fractures and the pattern was on the whole similar (Figure 31, Table A:IV). Also, the trend of change was similar to that of other distal forearm fractures.

Comment: Buhr & Cooke (1959) found a sex difference: fractures of the distal end of the forearm were twice as frequent in boys as in girls. The present study had a similar trend - the difference was, however, only apparent in the older children. The absolute incidences cannot be compared with those of Buhr & Cooke (1959) because of differences in the sampling procedure. Alffram & Bauer (1962) found no difference between the sexes although they had studied the very same population; their absolute incidence, however, was in good agreement with the observations from the first part of the time period covered by the present study.

Fracture of the distal end of the forearm i.e. the Colles' fracture may be a sign of reduced bone mass, a "fragility fracture" which may be an early - even the earliest - sign of osteoporosis (Bauer 1960, Alffram & Bauer 1962, Nilsson & Westlin 1974). In children, this fracture, the most common, is not so obviously related to the quality of the skeleton.

Neer & Horwitz (1965) found in a survey of 2,500 physeal fractures that the distal end of the radius contributed 46 per cent - the proportion was 41 per cent in the present study. Also, Peterson & Peterson (1972), in a detailed analysis of physeal injuries, including the hand and the foot, found the distal radial physis to be the one most frequently injured - 30 per cent.

The age distribution of the physeal fractures is the same as that of the metaphyseal. If the increasing fracture rate and the sex pattern are caused by growth spurts then the effects on growth cartilage and metaphyseal bone appear to be the same.

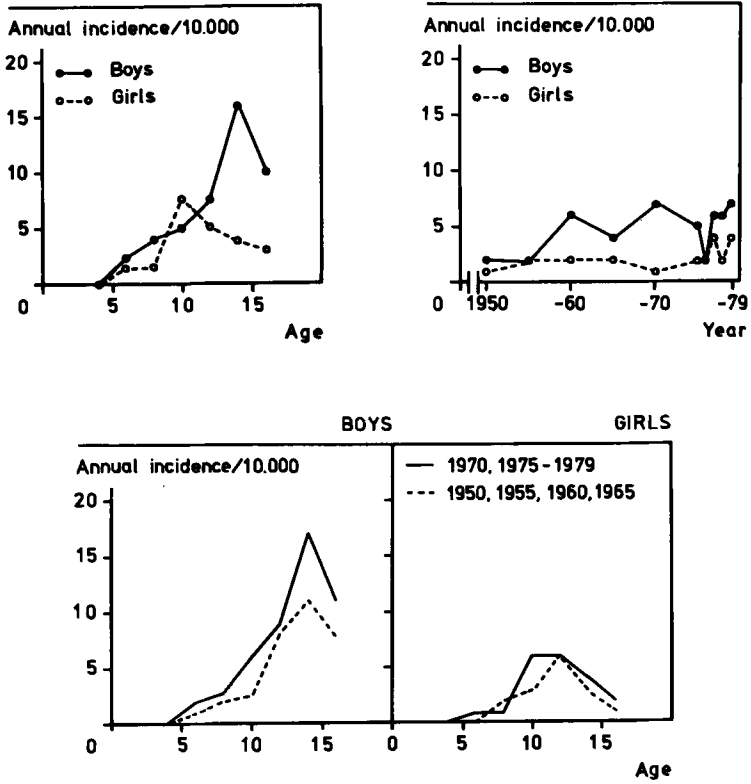


Figure 31. Physeal fractures of the distal end of the forearm, incidence in relation to age, sex and time.

Fractures of the phalanges of the hand

Fractures of the phalanges of the hand were the second most common fracture and contributed 19 per cent. The ratio boys/girls was 1.3/1. The incidence increased steeply to peaks of about 11 - 14 years. After age 12 the fractures were about 40 per cent more frequent in boys than in girls (Figure 32, Table A:V). In the age group 13 - 16, the sex difference could be explained by contact sports, skating, ice-hockey, playing and scuffles but not by the ball games. In both sexes, the risk of fracture more than doubled over the 30 years under observation ($p < 0.001$) (Figure 32). There was no significant increase with time in the youngest children but after age eight there was a similar increase in both sexes ($p < 0.001$) (Figure 32). Significant changes over the years were recorded with regard to activities causing falls, bicycle accidents, injuries to passengers in automobiles, ball games, gymnastics, athletics, contact sports and skiing, all significantly increasing between the first two decades and the last decade of the period under study.

Comment: In boys aged 13 - 14 years, the observed incidence was 104 per 10,000, which is the highest risk of any fracture type per age group recorded in this study. Buhr & Cooke (1959) also found a high incidence of fractures of the phalanges of the hand - in their study the most common fracture type during childhood and adolescence together with supracondylar fracture of the humerus - the fracture rate was nearly twice that recorded for fractures of the distal end of the forearm.

Carpal - metacarpal fractures

These fractures (including the carpal and metacarpal bones and excluding the scaphoid) contributed 8.3 per cent of the fractures in children, ranking number 3. There was a steep increase in risk after the age of 7 - 8 in boys (Figure 33, Table A:VI). These fractures were 8 times more common in boys than in girls in these age groups. Scuffles contributed 1/3 of the carpal-metacarpal fractures, 95 per cent of the scuffle fractures were in boys. In fractures caused by other activities such as falls, bicycle accidents, ball games, skiing, skating et cetera, the preponderance

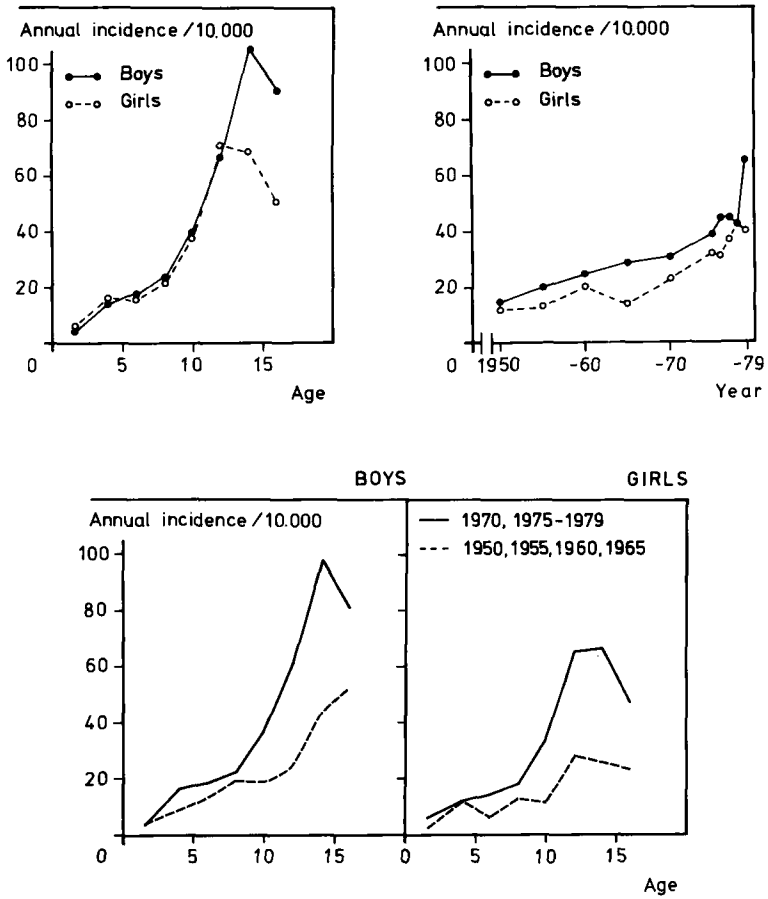


Figure 32. Fractures of the phalanges of the hand, incidence in relation to age, sex and time.

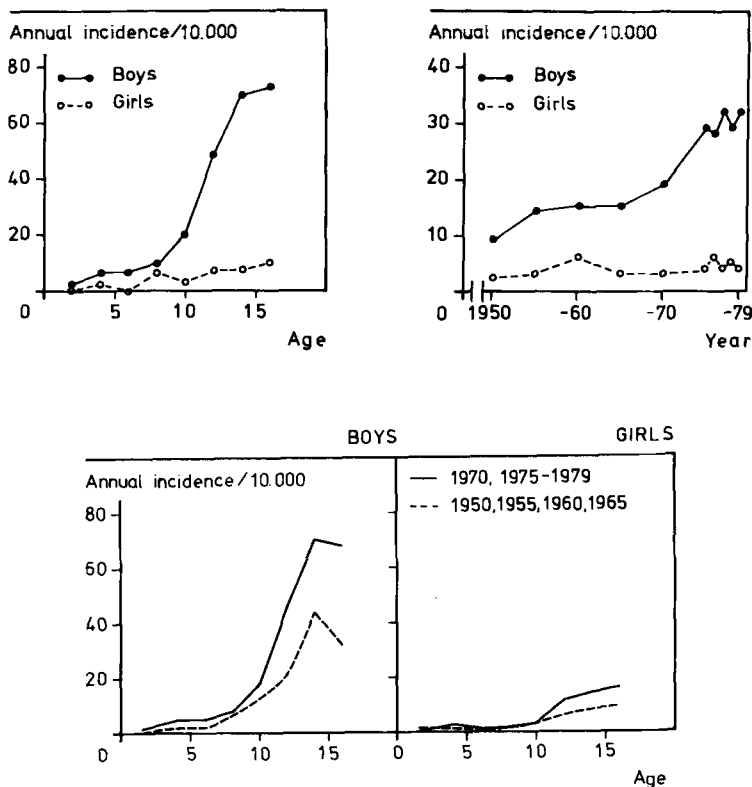


Figure 33. Carpal-metacarpal fractures, incidence in relation to age, sex and time.

for boys was similar in all age groups. Over the years the carpal-metacarpal fractures in boys increased by a factor of approximately three ($p < 0.001$) whereas there were no changes in girls (Figure 33). The change with time occurred almost entirely in children over the age of 10 (Figure 33). The most obvious causes of the increased risk of fracture in boys were scuffles, skiing and skating.

Comment: The age and sex distribution is in accordance with that found by Buhr & Cooke (1959). Kølle-Jørgensen (1971) also found that metacarpal fractures were frequently encountered in scuffles, particularly in older boys.

Fracture of the clavicle

Fractures of the clavicle contributed 8.1 per cent of all fractures, ranking number 4. The fracture was significantly ($p < 0.001$) more common in boys than in girls (1.5/1). There was a bimodal age-specific incidence in both sexes with the peak values at the age of 3 - 6 and 13 - 14, and with an intervening period of decreased incidence. Below the age of 11, there was no significant difference between the sexes (Figure 34, Table A:VII).

In younger children under 10, the non-specific falls were the most common cause of injury, in boys as well as in girls. Only a few had been hit by motor vehicles. After 10, activities such as ball games and contact sports became significantly more common ($p < 0.001$), boys dominating this group completely. Only horse accidents were significantly more frequent in girls ($p < 0.05$). The trend of change over the years was a slight but significant increase ($p < 0.05$) in both sexes, fairly evenly distributed between age groups (Figure 34).

Comment: This bimodal age distribution has also been found by Kølle-Jørgensen (1971) who recorded a predominance for boys. The ratio boys/girls in the present study was virtually the same as found by Buhr & Cooke (1959).

Ankle fractures

Ankle fractures, including also avulsion of fragments from tibia or fibula and fractures including the physes in the distal ends of the tibia and the fibula, contributed 5.5 per cent and ranked number 5 in frequency. The sex ratio was 1/1 and both sexes increased their risk rapidly with increasing age (Figure 35, Table A:VIII).

Below the age of 7, the most frequent cause of ankle fractures was a foot caught in a bicycle wheel, this type of accident having

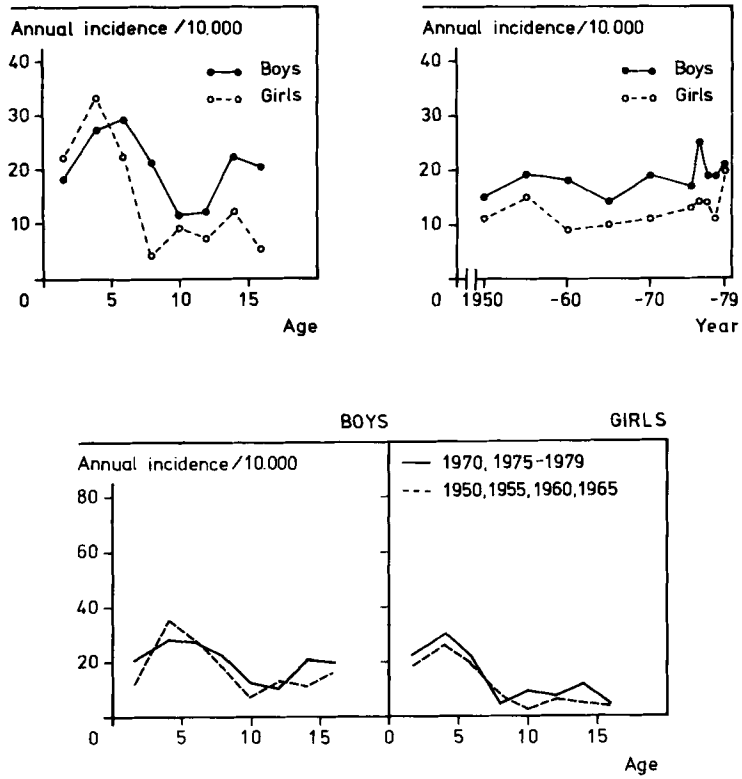


Figure 34. Clavicle fractures, incidence in relation to age, sex and time.

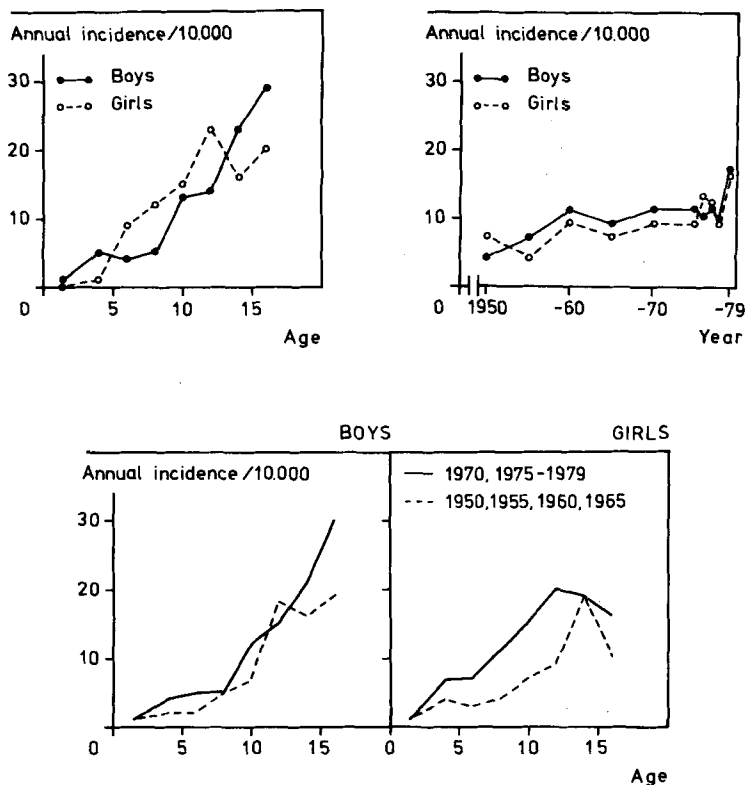


Figure 35. Ankle fractures, incidence in relation to age, sex and time.

remained unchanged over the years. In older children, unspecific falls were the most commonly recorded cause, but ball games, skateboard, roller skate, moped, motorcycle, skiing, skating, cycling and playing accidents also contributed.

Over the years the incidence of ankle injuries had more than doubled (Figure 35) ($p < 0.001$). Ball games, moped, motorcycle and falling from playground fixtures have contributed to this increase. Those injuries which were classified as ankle fractures merely because of an avulsion of a bony fragment from the tibia

or the fibula did not change in incidence over the years (Figure 28).

Comment: Kärrholm et al. (1982) recently calculated the ankle fracture incidence in children of the area surrounding the city of Malmö. The incidence was somewhat lower, the pattern was similar.

Fracture of the shaft of the tibia

Included were the diaphyseal tibial fractures with or without fracture of the fibula. The tibial fractures contributed 5.0 per cent to the fractures in children, number 6 in rank, with a sex-ratio of 2.2/1. There was an apparent three-modal distribution of fractures over the age-periods (Figure 36, Table A:IX), the modality was not statistically significant. Boys had more fractures from all sorts of activities and no particular tibial fracture causal activity was detected. However, in younger children, the fractures, particularly in boys, were related to toys and sporting equipment including bicycles, the danger of which apparently has decreased in the age group 11 - 12 where boys and girls had similar risks. Later in life, however, there were motorcycle and skateboard accidents, particularly in boys, who were now active participants in traffic.

There was a tendency of increase ($p < 0.05$) with time in the risk of tibia shaft fractures in boys with large fluctuations, whereas in girls there was a slow but significant decrease ($p < 0.05$) (Figure 36).

Comment: Kärrholm et al. (1982) found a similar pattern but a generally lower incidence. Also, for this fracture the sex ratio was the same as found by Buhr & Cooke (1959) more than 20 years ago. Kølle-Jørgensen (1971) observed 94 cases of tibial shaft fractures with an age and sex distribution similar to this series. Jonasch & Bertel (1981) - Austria - found a steady increase of this fracture type with age in a group of mainly skiing injuries. The age distribution of tibial shaft fractures in Singapore (Wong 1965) is similar to that observed in the present series with the highest incidence in the age group 5 - 9. From the incidence

numbers provided by Wong (1965) the risk of tibial fracture was more than twice as great in Malmö as in Singapore.

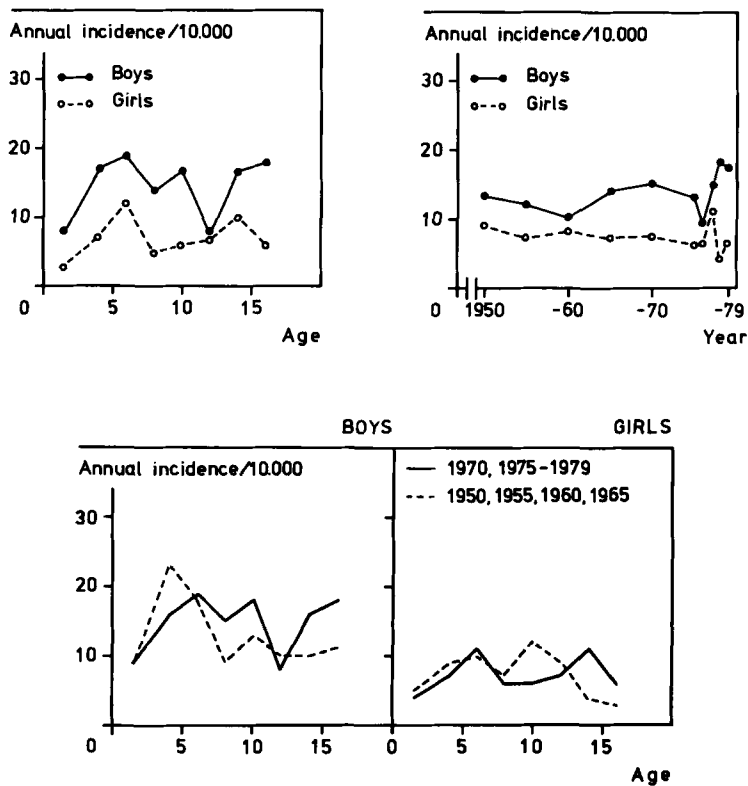


Figure 36. Tibia fractures, incidence in relation to age, sex and time.

Tarsal - metatarsal fractures

Included in this group were all fractures of the bones of the foot excluding the phalanges, the talus and the calcaneus. This group contributed 4.5 per cent and was number 7 in rank of frequency. The boy/girl ratio was 1.4/1. There was a tendency towards a bimodal age distribution (Figure 37, Table A:X) with playing fractures in the young children and falls, games, moped, motor-cycle and bicycle accidents in the older group. The sex difference could not be explained by any particular type of accident.

Over the years there was an increase in boys as well as in girls, significant, however, only in girls (Figure 37) ($p < 0.001$).

Comment: Data on the occurrence of these fractures is rare. Lichtenberg (1954) - USA - reported in a survey of 2,532 fractures in children, the frequency of fractures of the foot, to be 1.9 per cent. Pellerin et al. (1971) - Paris - found 2.2 per cent foot fractures among 3,458 fractures in children. In the Austrian survey by Jonasch & Bertel (1981) metatarsal fractures comprised 3 per cent with a peak value of occurrence at the age of 13, similar to the result in the present study.

Fractures of the toes

Included were all roentgen-diagnosed fractures of the toes. Fractures of the phalanges of the foot contributed 3.4 per cent and ranked number 8 in frequency. The boy/girl ratio was 1.5/1. The incidence increased rapidly with age to 13 - 14 (Figure 38, Table A:XII). In the older children it was most common in boys, due to ball games. Otherwise there was no sex difference. There was a significant increase in the number of diagnosed toe fractures over the years in boys ($p < 0.001$) as well as in girls ($p < 0.001$), ball games being one cause of the increase. Other causes could not be analysed (Figure 38).

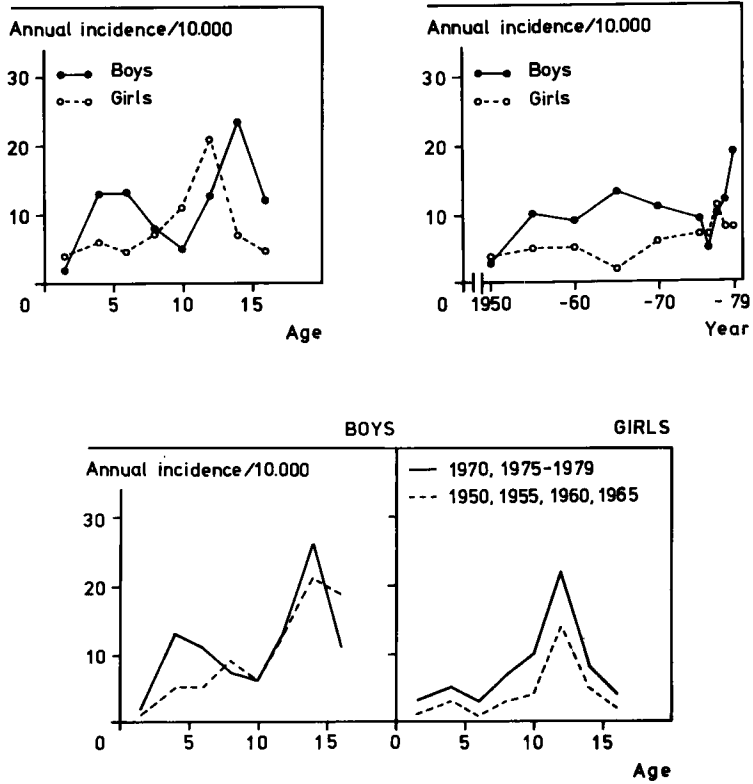


Figure 37. Tarsal-metatarsal fractures, incidence in relation to age, sex and time.

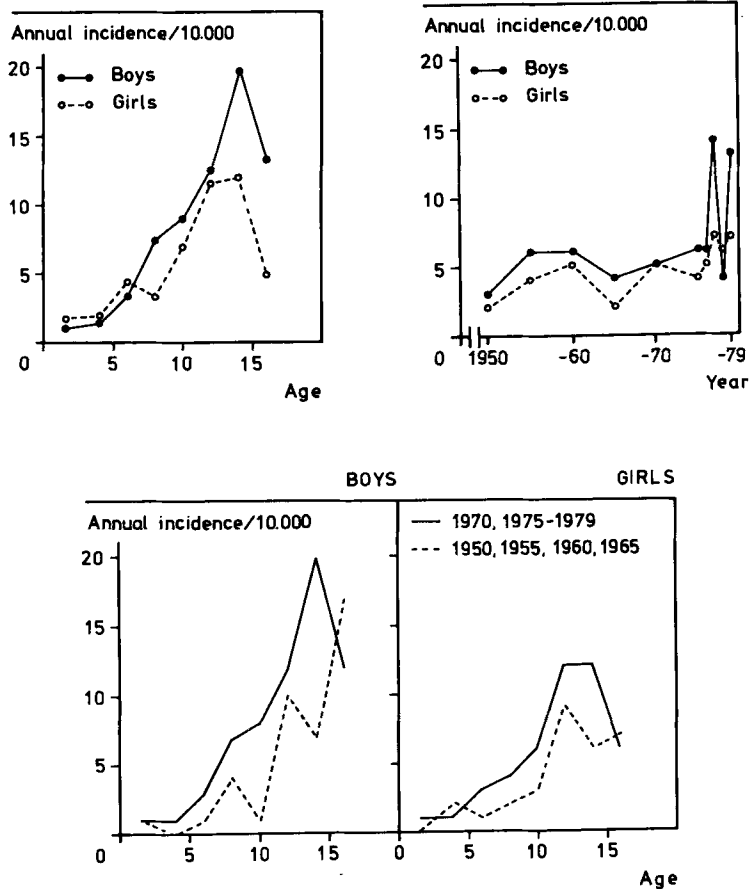


Figure 38. Toe fractures, incidence in relation to age, sex and time.

Fracture of the shaft of radius and/or ulna

Included in this group were all fractures of the radius distal to the radial tuberosity and proximal to the distal metaphysis. Also, all fractures affecting ulna except fractures of the olecranon and the distal metaphyseal region, were included.

Diaphyseal fractures of the forearm accounted for 3.4 per cent of the total number of fractures ranking number 9. The boy/girl ratio was 2/1. The incidence for boys had a bimodal shape with one peak in the age of 5 - 8 years and another peak in the age of 13 - 14 years.

The dip in incidence in boys aged 9 - 12 was significant ($p < 0.05$). In girls there was no second incidence peak and their highest incidence occurred in age group 5 - 6 (Figure 39, Table A:XII).

By and large the etiology was in the majority of cases falls without any specific environmental factors. Bicycle accidents contributed 10 per cent. Before the age of 10 non-specific falls were the cause of fracture in 50 per cent, followed by gymnastics, sport and bicycle accidents, each contributing an equal amount. In boys this type of fracture after the age of 11 became significantly more frequent - sport accidents and accidents due to falls being more common than in girls. Subtracting such fractures reduced the sex difference, which, however, remained significant ($p < 0.05$).

Comparing the last decade with the first two decades a significant reduction in incidence of this fracture type had taken place ($p < 0.05$) (Figure 39). In 5-10-year-old boys, fractures caused by falls decreased significantly (50 per cent, $p < 0.01$) resulting in a decreased total incidence (Figure 39). Otherwise, no statistically significant change was recorded for any environmental factors. In age 11 - 16, there was a significantly ($p < 0.01$) higher incidence of fractures sustained during sport, which, however, could not explain the entire increase in the oldest boys. There were also minor alterations in other environmental factors. In girls, a lower incidence was seen in the age

of 9-12 (Figure 39), the reduction was, however, not statistically significant.

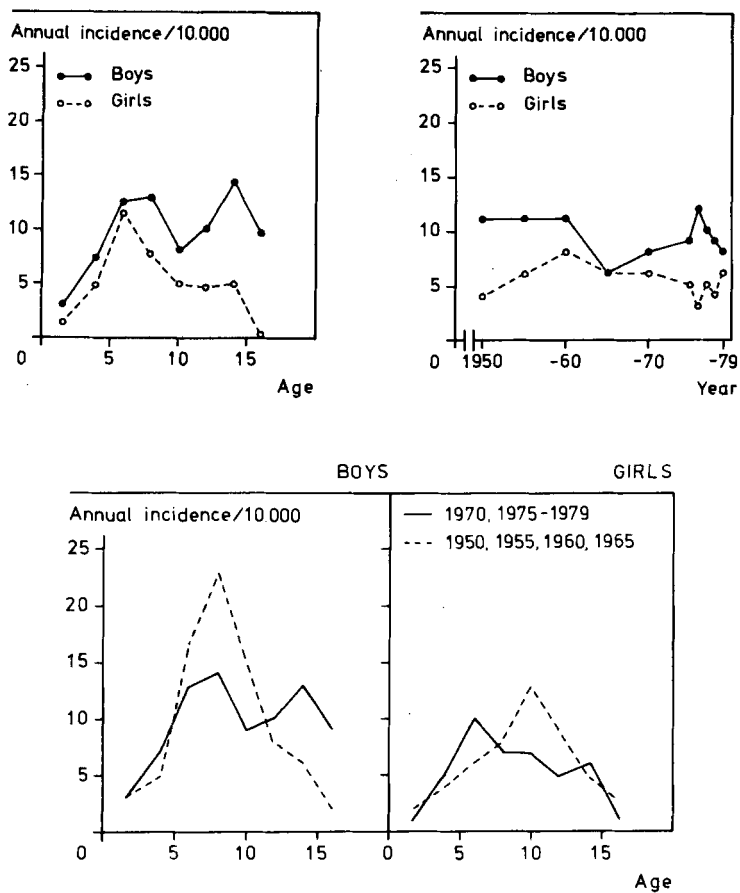


Figure 39. Fractures of the shaft of radius and/or ulna, incidence in relation to age, sex and time.

Comment: The peak incidence value for boys aged 13 - 14 found in this series during the last five years of the 1970's did not exist 1950-65 when the pattern was similar to that found by Wong (1965) 1962-63 in Singapore. The annual incidence in children 0 - 14 using the data of Wong was 6/10,000 among the children with Indian origin and 4/10,000 in Malay children; the latter was half of the early Malmö incidence in the same age groups. Variations with age and the difference between boys and girls appear to be similar in Singapore and Malmö. Jonasch & Bertel (1981) - Austria - found an age-dependent variation of the incidence with peak values at the age of 8 for boys as well as for girls; later the incidence decreased in girls so that this fracture became 7 times more common in boys. The sex difference was twice that recorded in the same age groups of the present series. In the Austrian report 17 per cent of the fractures were caused by various sports.

Supracondylar fracture of the humerus

Included were fractures with the fracture line in the metaphyseal region and proximal to the epiphyseal plate - condylar fractures were not included. The supracondylar fractures contributed 3.3 per cent of all fractures in children, ranking number 10. In young children there was no sex difference. After the age of 10 there was a small but significant preponderance for boys ($p < 0.01$). The overall boy/girl ratio was 1.3/1. The maximum incidence occurred at the age of 5 - 6. This fracture was rare in the very young and in the older children and in girls over the age of 12 it did not occur at all. A tendency of bimodality in girls appeared to be due to a change in behaviour, girls 7 - 8 were less likely to fall from heights (Figure 40, Table A:XIII). This bimodality, however, was not statistically significant.

The fracture incidence remained fairly constant over the years (Figure 40) - in boys the risk decreased slightly but significantly ($p < 0.05$). This reduction in risk was mainly due to changes between the age of 6 and 11 (Figure 40) when falls decreased in importance ($p < 0.01$).

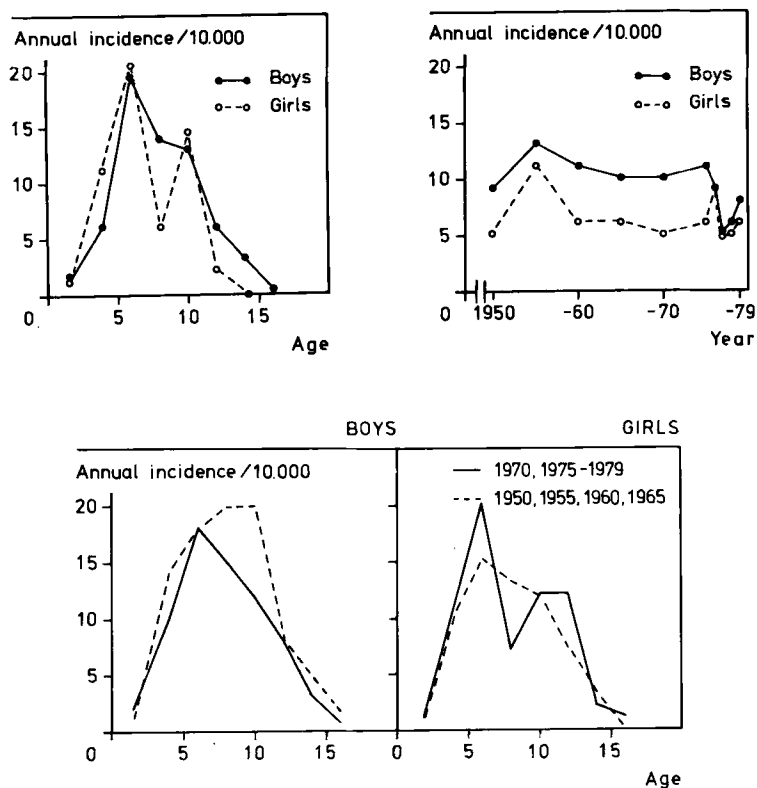


Figure 40. Supracondylar fractures of the humerus, incidence in relation to age, sex and time.

Comment: Henrikson (1966) in a late review of the results of supracondylar fractures of the humerus in children treated in Göteborg 1930 - 50, found a peak incidence at the age of 6 similar to this study. Henrikson also found that this fracture was produced by trauma worse than falling in the same level - climbing being the predominant cause. Traffic injuries contributed to a minority of the cases in spite of the increasing intensity of traffic during

the time period studied and the increase in the number of vehicles on the roads had but little influence on the number of supracondylar fractures. In 1930 - 50 there was an increase in risk. The incidence recorded in Göteborg during 1950 was virtually the same as in Malmö. Buhr & Cooke (1959) presented a similar age distribution for this fracture and in their study it was the most common fracture in children together with fractures of the hand phalanges. The age distribution was in accordance with reports from other parts of the world such as Stockholm (Holmberg 1945), Singapore (Wong 1965, 1966), Paris (Pellerin et al. 1971) and Austria (Jonasch & Bertel 1981). Also, the predominance of boys over girls was observed in these studies. From the data of Wong (1965), the incidence of supracondylar fractures of the humerus in Indian and Malay children in Singapore may be calculated. The annual risk for Indian children in Singapore of sustaining a fracture of the supracondylar region of the humerus was 6/10,000 and for Malay children 4/10,000, as compared with 8.6/10,000 for the children in Malmö in 1965.

Fracture of the proximal end of the humerus

This group included the fractures of the surgical neck, but also physeal fractures and contributed 2.2 per cent being the 11th among fractures in children. This was the only one of the more common fractures in children with a significant predominance for girls, boy/girl ratio 0.6/1 ($p < 0.001$). The sex difference was found entirely at the age of 9 - 14; before and after that age there was no difference between the sexes (Figure 41, Table A:XIV). Not less than 32 of 101 fractures were caused in horse-riding accidents, at the age of 9 - 12 horses were involved in half of the cases. Removing all horse-back injuries from the data (Figure 41) changed the pattern considerably, however, the preponderance of girls in this age group remained significant ($p < 0.01$).

There was no change over the years in the incidence in boys: in girls from 1970 onwards the incidence doubled (Figure 41) ($p < 0.001$). This was entirely explained by accidents associated with horse-riding.

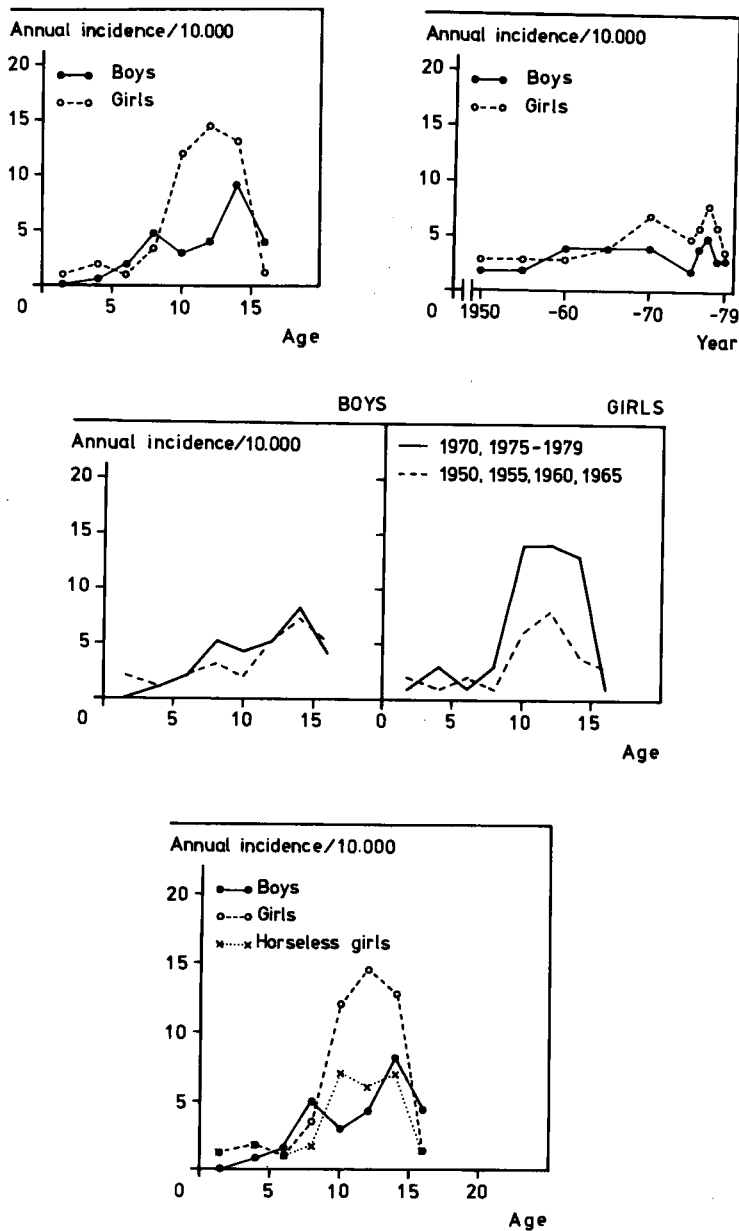


Figure 41. Fractures of the proximal end of the humerus, incidence in relation to age, sex and time.

Comment

The age distribution of this fracture was virtually the same as in Oxford (Buhr & Cooke 1959), Sidney (Lopez & Rennie 1969), Paris (Pellerin et al. 1971) and Austria (Jonasch & Bertel 1981). However, comparing the distribution between the sexes, the Malmö girls were unique in so far that they had more fractures of the proximal end of the humerus than the boys. In England, in the 1950's, this fracture was twice as common in boys as in girls. Apparently, the interest for horse-riding among the Malmö girls was responsible for the major part of the discrepancy. In a study on riding-accidents in Malmö, Danielsson & Westlin (1973) found the proximal end of the humerus to be the most frequently fractured region, together with the diaphysis of the forearm. Eight per cent of the patients seeking medical advice after falling from horse-back had fracture of the neck of the humerus. Gustafsson (1975), in a study of childhood accidents in Uppsala, also stressed the overwhelming predominance of girls in riding accidents - 50 out of 53 children injured in horse-back riding were girls.

Fracture of the upper end of the humerus has been ranked among the "fragility fractures" in adults. In young girls, however, the causing trauma is usually greater than average.

Skull fractures

Roentgen-diagnosed fractures of the skull contributed 1.8 per cent of all fractures in children during the time period 1975 - 1979 ranking number 13. The age and sex specific incidence is demonstrated in Figure 42, Table A:XV). The fractures were most common in the very young children and significantly more common in boys than in girls, boy/girl ratio 1.8/1 ($p < 0.05$).

In the young children, before the age of 5, falls were the most common trauma. After the age of 4 the activity of the child and environmental factors became more important; playground injuries, bicycles, hit by cars and, in a few instances, sport accidents.

In the analysis of the possible trends of change a slow but significant reduction was seen (Figure 42) ($p < 0.01$). The reduction was

obvious only in the younger children below 10 (Figure 42). When cases of fracture in pedestrians and car passengers were subtracted from both periods there was no difference.

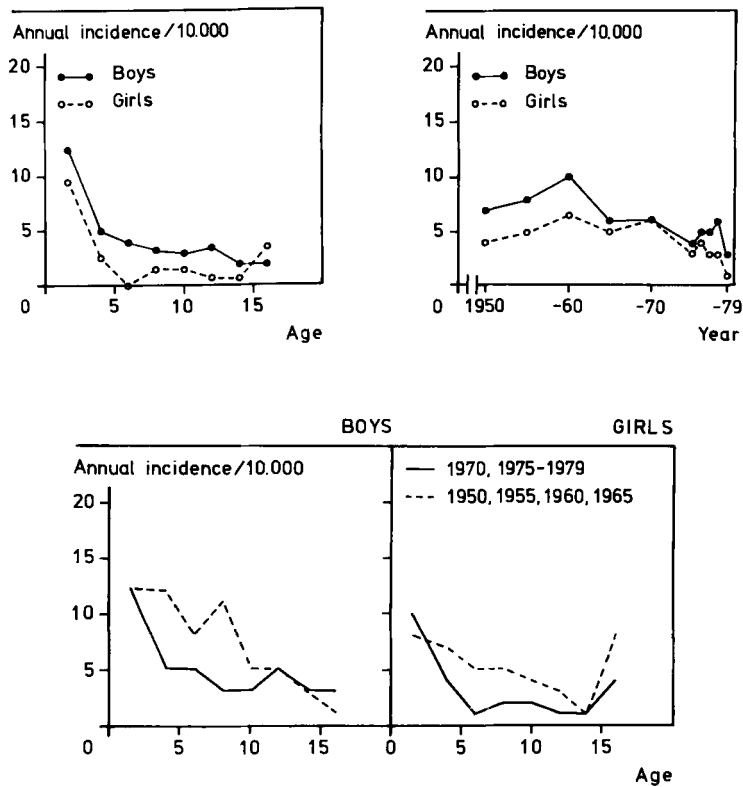


Figure 42. Skull fractures, incidence in relation to age, sex and time.

Comment: Skull fractures, diagnosed by roentgen, are common in toddlers and falls are the predominant trauma. When activity factors become more important, more fractures occur in boys. The reduction of skull fractures over the years was mostly seen in the high energy injuries such as traffic accidents which implies that an actual decrease in the trauma incidence rather than a change in the attitude to skull roentgen is the cause, even if in recent years arguments have been presented against unselective roentgen examinations after skull trauma (Bergström et al. 1975, Borgström 1975, Palmertz 1975) - those escaping roentgen examination recently should have been those with a less severe trauma.

Fracture of the shaft of the femur

Included were the subtrochanteric and the supracondylar regions; excluded the cervical, the trochanteric and the condylar fractures. These fractures contributed 1.6 per cent and ranked number 14. The boy/girl ratio was 2.3/1. The incidence appeared to have a bimodal distribution with a peak value in young children and one in the young teenagers (Figure 43, Table A:XVI). The boys were predominant only among the younger children.

The most frequent circumstances of injury were accidents at home in conjunction with playing and falling. There were also accidents related to sleighs, pedal cars et cetera - these were on the whole low energy trauma whereas in the older children traffic accidents were the most common cause of femur fractures.

There was a significant ($p < 0.001$) increase in the risk of femur fracture in children over the years (Figure 43). The increase was most obvious in young boys and in older girls (Figure 43). In the younger age groups toys and playing equipment contributed most to the increase in risk. Otherwise the data do not permit further analysis.

Comment: The sex distribution agrees with the data presented on this fracture from Austria (Jonasch & Bertel 1981). The peak incidence in Singapore (Wong 1965, 1966) was in older children - the total incidence was one third of that in Malmö.

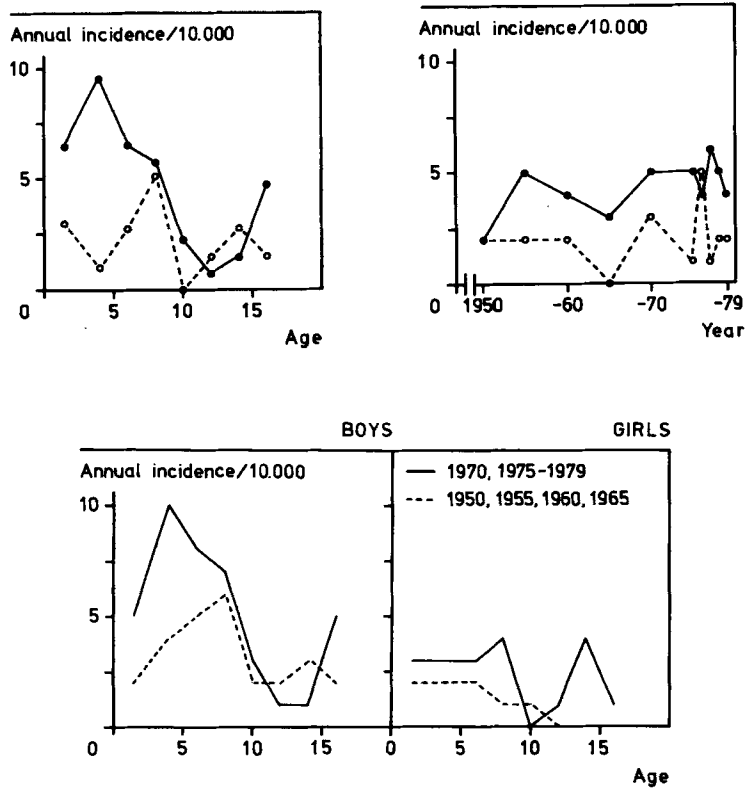


Figure 43. Femur diaphysis fractures, incidence in relation to age, sex and time.

Other types of fracture

Apart from the 13 types of fracture analysed it may be of interest to calculate, roughly, the total incidence also of some fractures that did not occur in sufficient numbers for subdivision in age and sex groups. These fractures are listed in Table 10 and for the incidence calculation all 10 years under observation (1950, 1955, 1960, 1965, 1970 and 1975-1979) were used.

Table 10. Incidence of other fractures (8.682 fractures involved).

Type of fracture	Number observed	Annual incidence per 10,000
Humerus, diaphysis	58	1.20
Fracture of the lateral condyle of the humerus	77	1.60
Fracture of the medial epicondyle of the humerus	62	1.29
Radial neck	92	1.91
Galeazzi	9	0.19
Monteggia	2	0.04
Scaphoid (avulsions excluded)	48	1.00
Vertebral fractures	76	1.58
Pelvic	43	0.89
Femur, cervical	2	0.04
Femur, trochanteric	2	0.04
Tibial spine	17	0.35
Talus (avulsions excluded)	6	0.12
Os calcis (avulsions excluded)	20	0.41

Re-fractures

Those fractures occurring on the same site as a previous fracture within one year were classified as re-fractures. This criterion was met by 21 out of 4,621 fractures 1975-1979. The re-fracture rate was 0.5 per cent and occurred after, on average, 4.1 ± 3.3 months. The various types of re-fracture and the re-fracture rate for each fracture type are listed in Table 11.

Table 11. Re-fractures of various locations.

Type	Number	Re-fracture rate Per cent
Clavicle	1	0.5
Proximal end of the humerus	1	1.0
Humerus, diaphysis	1	5.3
Radius-ulna, diaphysis	5	3.2
Distal forearm	8	0.8
Carpal-metacarpal (scaphoid excluded)	3	0.9
Tibia, diaphysis	1	0.4
Tarsal-metatarsal (talus, os calcis excluded)	1	0.5

GENERAL DISCUSSION

Incidence

The total incidence of fractures in childhood may be compared between various periods and various parts of the world (Table 12). About half of the investigators have not had access to the population at risk and therefore the fracture risk can be calculated only as a percentage of the total number of accidents in children. The proportion of fractures seems to be on average 20 per cent but the range is between 7 and 36 per cent, probably depending mostly on the definition of accident in a child and on the organisation of the health care system. Those who present frequency data and a denominator obtained from some sort of risk population also agree fairly well with one another and with the data of the present study. The Malmö data in Table 12 were chosen to correspond as closely as possible with regard to time and age distribution to those of the study to be compared with. In a few cases, surprisingly, data which should be similar to those of the Malmö population - from Göteborg and Odense - more fractures were found. A possible explanation is that the Göteborg and the Odense data were obtained from the records of the patients whereas the Malmö data was based on diagnosis recorded in the Department of Diagnostic Radiology. However, the differences may be real. Garraway et al. (1979) presented data on the incidence of limb fractures from Rochester, Minnesota, where the conditions are favourable for fracture epidemiological studies, similar to those in Malmö. The risk in 1970 of sustaining a fracture of the upper or lower extremity was virtually the same in the two cities comparing age groups 0 - 14.

Fracture patterns

Buhr & Cooke (1959) managed to describe the age specific incidence as specific patterns typical of various fractures. An attempt was made in the present study to arrange fractures in children in a similar way, starting out from the visual patterns of the age specific incidence (Figure 44). The late peak pattern: mostly sport and equipment related. The bimodal pattern includes an early increase in incidence due to low energy trauma followed by a late incidence peak due to high or moderate energy trauma,

Table 12. Proportion of fractures in various studies of children's accidents. The incidence has been calculated whenever the authors have presented suitable data and compared with observations from Malmö (in brackets) as close in time as possible and using corresponding age groups.

Author	Country	Period under study	Number of accidents	Per cent Fractures	Annual incidence per 10,000	(Malmö)
Hindmarsh et al, 1946	Stockholm, Bäckefors, Sweden	1930 - 1939	5,083	26		
Berfenstam et al, 1957	Stockholm, Sweden	1955	24,466	16	170	(160)
Gustafsson 1975	Uppsala, Sweden	15.9. 1972 - 14.9. 1973	3,069	11	118	(172)
Mathorst Westfelt 1982	Göteborg, Sweden	10.11.1975 - 10.11.1976	11,888	17	240	(198)
Kølle-Jørgensen 1971	Odense, Denmark	1.4. 1959 - 31.3. 1960	4,820	24	225	(173)
Born 1961	Kiel, West Germany	1949 - 1958	3,218	36		
Panzner 1966	Halle, East Germany	1953 - 1962	8,532	25		
Engler 1967	Bratislava, Czechoslovakia	1959 - 1964	51,533	21	178	(173)
Reiner et al, 1979	Wien, Austria	1976	2,977	26		

Illingworth 1977	Sheffield England	1.3 - 31.5, 1.8 - 31.8, 1.11-30.11.1977	431	22	
Maddocks et al. 1978	Cardiff, Wales	19.10-15.11.1976	1,498	10	
Sibert et al. 1981	Cardiff, Wales	1.5 - 31.10.1977	9,989	14	
Pellerin et al. 1971	Paris, France	1964 - 1966	13,433	25	
Bardier et al. 1981	Toulouse, France	1.6.1973 - 31.12.1978	3,683	18	
Stallones & Corsa 1961	California, U.S.A.	1957	27,623	7	(173)
Manheimer et al. 1966	California, U.S.A.	1941 - 1960	13,154	21	(182)
Izant & Hubay 1966	Cleveland, U.S.A.	1.7.1964 - 30.6.1965	5,646	9	
Lopez & Rennie 1969	New South Wales, Australia	1967	2,272	20	(140)

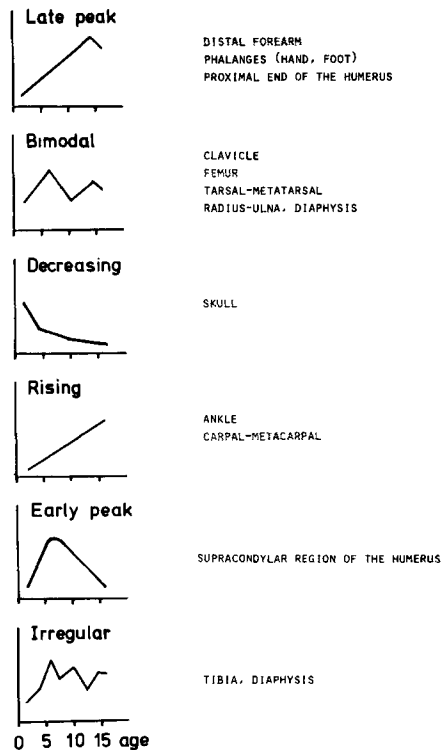


Figure 44. Fracture patterns.

again, sports, traffic and similar. The decreasing pattern, typical of skull fractures only. The rising pattern is closely related to sports, skateboards, bicycles and similar activities which increase as the children grow, particularly in boys. In the ankle, however, within the next two years after 16 an adult pattern will be assumed (Kärrholm et al. 1982). Finally, the early peak pattern of the supracondylar fracture, mostly due to falling from higher levels, and the irregular pattern of the tibia shaft, again confirmed by Kärrholm et al. (1982) are unique for those particular fractures.

Secular changes

There were in many, in fact in most, types of fracture, a significant increase in the incidence over the last three decades. The secular change for each type of fracture is demonstrated in Table 13. An obvious objection is that some fractures in the early period under observation may have escaped detection since the parents may have been less inclined to seek medical advice at that time, and the physicians less inclined to order a roentgen examination. Also, the introduction of compensation for medical expenses might have encouraged the parents and/or physicians to require roentgen examinations. From January 1st, 1970 on, patients do not pay for roentgen examinations and in many fracture types and in the overall incidence the pattern suggests a small step-wise increase from that year on. Also, the increase was greatest for the undisplaced fractures that did not require reduction - again, such fractures may have been neglected and not diagnosed during the early part of the time period. Finally, diaphyseal fractures, usually caused by more violent trauma than the metaphyseal injuries, did not, on the whole, increase over the years.

Table 13. Changes with time for various fracture types. The last decade compared with the two first decades.

<u>Increased incidence</u>	<u>Unchanged incidence</u>	<u>Decreased incidence</u>
Distal end of the forearm	Carpal-metacarpal (girls)	Tibia, diaphysis (girls)
Hand phalanges	Tarsal-metatarsal (boys)	Supracondylar region of the humerus (boys)
Carpal-metacarpal (boys)	Supracondylar region of the humerus (girls)	Radius-ulna, diaphysis
Clavicle	Proximal end of the humerus (boys)	Skull
Ankle		
Tibia, diaphysis (boys)		
Tarsal-metatarsal (girls)		
Phalanges of the foot		
Proximal end of the humerus (girls)		
Femur, diaphysis		

However, the diaphyseal fractures were more frequently caused by high energy trauma which did not increase over the years, and one of the diaphyseal fractures which should not be possible to neglect - fracture of the femur shaft - did increase and this increase could be explained by an increased number of accidents related to toys and sporting equipment. On the whole, most of the changes were possible to explain by environmental factors or could, at least, not be explained by changes in the attitude towards roentgen examinations - the differences between the sexes with regard to change with time, which were observed in some fractures cannot be explained in that way (distal end of the forearm, ankle and proximal end of the humerus).

Endogenous causes of fracture

Is it possible to relate the fracture risk to properties of the fracture victims? There are no data on such relationships in children with fractures but accident repeaters have been investigated in the past. Psychological characteristics and personality have been suggested to influence the accident rate (Fuller 1948, Krall 1953, Manheimer & Mellinger 1967). On the other hand, Padilla et al. (1976) and Jones (1980), in a review, found no difference between accident repeaters as compared with other children; environmental, including social factors would rather be the cause of repeated accidents. Also, in an investigation of childhood accidents Gustafsson (1972) found no psychological deviations in children with accidents compared with a control group. Nathorst Westfelt (1982) found that accident repeaters in Göteborg were more often socially handicapped than children with a single accident. With regard to deviations in the physical constitution of children and the relationship to fractures very little is known. The extremes (osteogenesis imperfecta, renal osteodystrophy, hereditary rickets) may, of course, come with numerous fractures but is there any variation within the normal range? In the elderly, some fractures have been recognized to be typical of bone fragility for the reason that they occur in the elderly and more often in women and that they are usually caused by a slight trauma. There is also evidence that these fractures are associated with a below average bone mineral content (Vose & Lockwood 1965, Nilsson & Westlin 1977).

In such patients the bone mineral content - the bone mass - is usually on the low side within the normal variation. Recently, Landin & Nilsson (1983) found a similar phenomenon in children who had sustained fracture after a slight trauma; there was a reduction of the bone mineral mass which was not related to body size or skeletal dimensions, indicating that also among children there is a subset which may be fracture-prone because of a lower than average quality of their bones. The attempt in the present study to find fractures in children which could correspond with the fragility fractures in the elderly was not very successful. If there are such fractures they are at least not identical with those in the elderly, except possibly for fractures of the distal end of the forearm which frequently are caused by low energy trauma in children as well as in old women. This fracture type, however, is in children the most common, regardless of the severity of the trauma. Also, although boys have a higher fracture rate, they also have a higher bone mineral content than girls of the same chronological age (Mazess & Cameron 1972, Krabbe et al. 1979, Landin & Nilsson 1981).

Exogenous causes of fracture

Whereas the child mortality in this century in Sweden has decreased by a factor of 10, the accident deaths have remained virtually constant over the years (Ehrenpreis 1973). During the last three decades, however, there was a reduction of fatal accidents - the incidence rate in children 0-14 years in 1975 was half of that in 1951 (Berfenstam 1979). This may not necessarily mean that the risk of major injuries has decreased, also modern treatment of trauma may have improved the chance of survival. Traffic and particularly motor vehicle accidents should have increased over the years since in 30 years the abundance of automobiles in Sweden has increased by a factor of 9, to be one of the highest in the world. The motor cycles, on the other hand, have changed in number in the opposite direction; mopeds - light motor cycles, which could be used by 15-year olds without a license - were three times as common in the 1960's as today.* The data on fractures in the present study is another way of

* Trafiksäkerhetsverket, Borlänge, Sweden.

monitoring the risk introduced by the traffic to the child population. The most serious accidents, those involving motor vehicles, have not increased significantly over the years, the only exception being possibly the introduction of the mopeds in the 1950's which caused accidents in boys. Of the total increase in traffic accidents, which does not nearly compare with the increase in traffic, bicycles rather than motor vehicles contribute most, fortunately with less severe accidents. Wallberg (1957), Lindgren et al. (1969) also pointed out that the intensity of traffic is not necessarily related to a high risk of traffic accidents. Also, there has been a significant reduction - 44 per cent - in the incidence of lethal traffic accidents in children 0-16 years during the 1960's and 1970's* (Figure 45). Pettersson & Hügard (1982) also suggested that the decreased traffic death rate in children was due to better traffic planning, information and education of children as well as parents. Possibly, also the fairly constant incidence of fractures due to traffic accidents over the years, in spite of an increasing traffic intensity, is due to the efforts to separate children and motor vehicle traffic in the city. Bicycle injuries may have been much more frequent, had not efforts been made to connect housing areas, schools and playgrounds with bicycle paths.

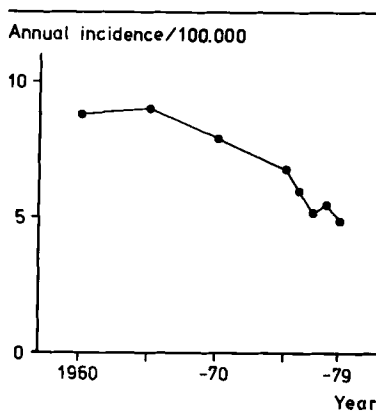


Figure 45. Changes in the incidence of lethal traffic injuries in children, 0 - 16 years.

* Statistical Abstracts of Sweden 1961, 1966, 1971, 1976, 1977, 1978, 1979, 1980. Central Bureau of Statistics, Stockholm.

A type of injury which is probably specific for this part of the world is encountered by a child being a passenger on a bicycle and having its foot caught in the spokes of the wheel. Fractures due to this were seen in just over one child per 10,000 every year in the city of Malmö. Information to the public about this injury has changed nothing, for 30 years it has occurred with the same rate.

The contribution of traffic to the total number of fractures in the present study was 12 per cent. This is an order of magnitude often observed in studies of accidents in children (Berfenstam et al. 1957, Panzner 1966, Kølle-Jørgensen 1971, Gustafsson 1975).

Even if traffic accidents are still a serious problem, playing and sports contribute a much larger quantity of accidents leading to fracture (Table 2). Sport injuries although contributing only 21 per cent of the fractures in children, are responsible for half of the increase over the years. Even, as discussed above, part of the apparent increase in minor fractures may be due to more roentgen examinations, there is an increasing trend of injuries due to sport and other similar activities often related to various types of equipment. The fracture rate is a mirror of our society - 20 per cent of 16-year-old boys are enrolled in association football* and many more are playing. Also, the number of children enrolled in other sports have been increasing over the years. One example is girls playing soccer with an impressive increase in fracture rate as a result.

Even if we have succeeded, to some extent, to protect our children from traffic accidents, our affluence has provided new dangers. Fortunately, these new injuries are usually less serious and society appears to be able to accept such morbidity in children as well as in adults.

The aim of our measures must be to prevent serious injuries and not to put a curb on those activities which are necessary for the normal development of children (Gustafsson 1972, 1975, 1977, Berfenstam 1979).

* Svenska Fotbollsforbundets Årsskrift 1979.

SUMMARY AND CONCLUSIONS

Age, sex, type of fracture and the circumstances causing the injury were studied in altogether 8,682 fractures in children, aged 0 - 16, which had occurred 1950, 1955, 1960, 1965, 1970 and 1975 - 1979.

For studies of incidence, the years 1975 - 1979 were chosen and for secular trend studies 1950, 1955, 1960, 1965, 1970 and 1975 - 1979.

The following conclusions may be drawn:

1. The risk of fracture increased with age up to age 11 - 12 in girls and 13 - 14 in boys.
2. The accumulated risk of fracture was 27 per cent in girls and 42 per cent in boys.
3. Fractures were more common in boys of all age groups.
4. Over the last three decades the risk of fracture was doubled in boys as well as in girls.
5. Over the years more and more fractures were caused by slight trauma whereas the more severe trauma - even if increasing somewhat in risk - contributed a smaller fraction of the injuries.
6. For the various types of fracture the pattern of change could differ - some increased in incidence, whereas some remained unchanged or even decreased.
7. All types of trauma - horse riding accidents excluded - were more frequent in boys.
8. The most commonly fractured region was the distal end of the forearm followed by the phalanges of the hand and the bones of the carpal-metacarpal region.

9. Playing, sports and traffic, in that order contributed 24, 21 and 12 per cent of those fractures in which the circumstances of the accident could be analysed.
10. Traffic accidents increased with one third in boys as well as in girls.
11. The passive participants in traffic - pedestrians and passengers in motor vehicles - were not more frequently injured during the latter part of the period under observation - a tendency of increase in girls was compensated for by a decrease in boys.
12. Sports and various playing activities as a cause of fracture increased with a factor of five.
13. In the upper limb, the left side was most frequently fractured.
14. The occurrence of fractures varied with the seasons with peak values in May and August and low values in July and December.
15. No fracture type in children could completely meet the criteria of a fragility fracture such as seen in old age.
16. Sustaining one fracture carried an increased risk of an additional fracture especially in the very young children.
17. Fractures not requiring reduction increased the most over the years.
18. The subset of children with various diseases suspected to interfere with skeletal development carried an increased risk of fracture.
19. Some age-related fracture patterns could be traced but they were not very distinct.

REFERENCES

- Abdon, N.J. & Nilsson, B.E. (1980) Episodic cardiac arrhythmia and femoral neck fracture. *Acta Med. Scand.* 208, 73-76.
- Alffram, P.-A. & Bauer, G.C.H. (1962) Epidemiology of fractures of the forearm. A biomechanical investigation of bone strength. *J. Bone Joint Surg.* 44-A, 105-114.
- Alffram, P.-A. (1964) An epidemiologic study of cervical and trochanteric fractures of the femur in an urban population. *Acta Orthop. Scand., Suppl.* 65.
- Andrén, L. & Borgström, K.-E. (1958) Seasonal variation of epiphyseolysis of the hip and possibility of causal factor. *Acta Orthop. Scand.* 58, 22-26.
- Barden, H.S., Mazess, R.B. & Chesney, R.W. (1983) Anticonvulsant osteomalacia in children. *Metabol. Bone Dis. Rel. Res.* In press.
- Bardier, M., Richaud, N., Horvath, E., Ayrolle, C., Guiter, C. & Gaubert, J. (1981) Les urgences traumatologiques infantiles. Etude analytique et statistique sur 6 ans. *Chir. Pédiatr.* 22, 231-236.
- Bauer, G.C.H. (1960) Epidemiology of fracture in aged persons. A preliminary investigation in fracture etiology. *Clin. Orthop.* 17, 219-225.
- Berfenstam, R. (1957) A critical review on different types of accident morbidity studies. *Courrier* 7, 349-361.
- Berfenstam, R., Ehrenpreis, Th., Ekström, G., Garsten, P. & Myrin, S.-O. (1957) Barnolycksfallen i Stockholm år 1955. *Svenska Läk.-Tidn.* 54, 1950-1973.
- Berfenstam, R. (1979) Prevention of childhood accidents in Sweden. With special attention to the work of the Joint Committee for Prevention of Accidents. *Acta Paediatr. Scand., Suppl.* 275, 88-95.
- Bergström, K., Lodin, H. & Sjövall, A. (1975) Diagnostiskt utbyte av skullröntgen i traumatiska och icke traumatiska fall. *Läkartidn.* 72, 4164-4166.
- Borgström, E. (1975) Skullröntgen vid akuta skullskador. *Läkartidn.* 72, 2286-2288.
- Borm, D. (1961) Unfälle im Kindesalter. Übersicht über 10 Jahre (1949 bis 1958). *Bruns Beitr. Klin. Chir.* 203, 221-233.

- Bruns, P. (1886) Die Lehre von den Knochenbrüchen. Verlag von Ferdinand Enke, Stuttgart.
- Buhr, A.J. & Cooke, A.M. (1959) Fracture patterns. *Lancet* 1, 531-536.
- Chesney, R.W., Mazess, R.B., Rose, P.G. & Jax, D.K. (1977) Bone mineral status measured by direct photon absorptiometry in childhood renal disease. *Pediatrics* 60, 864-872.
- Dahlquist, G., Gustavsson, K.H., Holmgren, G., Hägglöf, B., Larsson, Y., Nilsson, K.O., Samuelsson, G., Sterky, G., Thalme, B. & Wall, S. (1982) The incidence of diabetes mellitus in Swedish children 0-14 years of age. *Acta Paediatr. Scand.* 71, 7-14.
- Danielsson, L.G. & Westlin, N.E. (1973) Riding accidents. *Acta Orthop. Scand.* 44, 597-603.
- Ehrenpreis, Th. (1973) Prevention of childhood accidents in Sweden. The Swedish Institute, Göteborg.
- Engler, I. (1967) Die Unfälle im Kindesalter. *Z. Kinderchir.* 4, 48-58.
- Farkas, R. & Levine, S. (1950) X-ray incidence of fractured clavicle in vertex presentation. *Amer. J. Obstet. Gynec.* 59, 204-206.
- Fuller Mechem, E. (1948) Injury-prone children. *Amer. J. Orthopsychiat.* 18, 708-723.
- Garraway, W.M., Stauffer, R.N., Kurland, L.T. & O'Fallon, W.M. (1979) Limb fractures in a defined population. I. Frequency and distribution. *Mayo Clinic Proc.* 54, 701-707.
- Grunewald, K. (1979) Mentally retarded children and young people in Sweden. Integration into society: the progress in the last decade. *Acta Paediatr. Scand., Suppl.* 275, 75-84.
- Gustafsson, L.H. (1972) Barnolycksfall i Östersund. En studie över skilda faktorerers betydelse för uppkomsten av olycksfall bland barn före skolåldern. *Socialmedicinsk tidskrifts skriftserie nr 38*, Stockholm.
- Gustafsson, L.H. (1975) Barnolycksfall i Uppsala. I. En beskrivande epidemiologisk undersökning av barnolyckor i Uppsala under en 1-årsperiod. *Socialmedicinsk tidskrifts skriftserie nr 40*, Stockholm.
- Gustafsson, L.H. (1977) Childhood accidents. Three epidemiological studies on the etiology. *Scand. J. Soc. Med.* 5, 5-13.

- Hanlon, C.R. & Estes, W.L. (1954) Fractures in childhood - A statistical analysis. *Amer. J. Surg.* 87, 312-323.
- Henrikson, B. (1966) Supracondylar fracture of the humerus in children. A late review of end-results with special reference to the cause of deformity, disability and complications. *Acta Chir. Scand.*, Suppl. 369.
- Hindmarsh, J., Melin, G. & Melin, K.-A. (1946) Accidents in childhood. *Acta Chir. Scand.* 94, 483-514.
- Holmberg, L. (1945) Fractures in the distal end of the humerus in children. *Acta Chir. Scand.* 92, Suppl. 103.
- Horak, J. & Nilsson, B.E. (1975) Epidemiology of fracture of the upper end of the humerus. *Clin. Orthop.* 112, 250-253.
- Illingworth, C.M. (1977) Paediatric accident and emergency: Medical or surgical? *Publ. Hlth., Lond.* 91, 147-149.
- Iqbal, Q.M. (1974) Long bone fractures among children in Malaysia. *International Surgery* 59, 410-415.
- Izant, R.J. & Hubay, C.A. (1966) The annual injury of 15,000,000 children: A limited study of childhood accidental injury and death. *J. Trauma* 6, 65-74.
- Jonasch, E. & Bertel, E. (1981) Verletzungen bei Kindern bis zum 14. Lebensjahr. Medizinisch-statistische Studie über 263,166 Verletzte. *Hefte Unfallheilkd.* 150, 1-146.
- Jones, J.G. (1980) The child accident repeater. A review. *Clinical Pediatrics* 19, 284-288.
- Krabbe, S., Christiansen, C., Rødbro, P. & Transbøl, I. (1979) Effect of puberty on rates of bone growth and mineralisation. *Arch. Dis. Childh.* 54, 950-953.
- Krall, V. (1953) Personality characteristics of accident repeating children. *J. abnorm. soc. Psychol.* 48, 99-107.
- Kristensson, H., Lundén, A. & Nilsson, B.E. (1980) Fracture incidence and diagnostic roentgen in alcoholics. *Acta Orthop. Scand.* 51, 205-207.
- Kärrholm, J., Hansson, L.I. & Svensson, K. (1982) Incidence of tibio-fibular shaft and ankle fractures in children. *J. Pediatr. Orthop.* 2, 386-396.
- Kølle-Jørgensen, P. (1971) Child accidents. A medico-social study of 4,820 accidents. *Diss. Munksgaard, Copenhagen.*

- Landin, L. & Nilsson, B.E. (1981) Forearm bone mineral content in children. Normative data. *Acta Paediatr. Scand.* 70, 919-923.
- Landin, L. & Nilsson, B.E. (1983) Bone mineral content in children with fractures. *Clin. Orthop.* In press.
- Lichtenberg, R.P. (1954) A study of 2,532 fractures in children. *Amer. J. Surg.* 87, 330-338.
- Lidgren, L. & Wallöe, A. (1977) Incidence of fractures in epileptics. *Acta Orthop. Scand.* 48, 356-361.
- Lindgren, O., Lindström, S. & Gunnarsson, S.O. (1969) Trafikolyckornas samband med trafikmiljön. Barnolyckor i Göteborg 1964-1966 stadsdelsvis. En regressionsanalytisk studie. Chalmers Tekniska Högskola - Institutionen för stadsbyggnad, meddelande 23.
- Lopez, W.A. & Rennie, T.F. (1969) A survey of accidents to children aged under 15 years seen at a district hospital in Sidney in one year. *Med. J. Aust.* 1, 806-809.
- Maddocks, G.B., Sibert, J.R. & Brown, B.M. (1978) A four week study of accidents to children in South Glamorgan. *Publ. Hlth. Lond.* 92, 171-176.
- Manheimer, D.I., Dewey, J., Mellinger, G.D. & Corsa, Jr., L. (1966) 50,000 child-years of accidental injuries. *Publ. Hlth. Rep.* 81, 519-533.
- Manheimer, D.I. & Mellinger, G.D. (1967) Personality characteristics of the child accident repeater. *Child Develop.* 38, 491-513.
- Mazess, R.B. & Cameron, J.R. (1972) Growth of bone in school children: Comparison of radiographic morphometry and photon absorptiometry. *Growth* 36, 77-92.
- Mischler, E.H., Chesney, P.J., Chesney, R.W. & Mazess, R.B. (1979) Demineralization in cystic fibrosis. Detected by direct photon absorptiometry. *Amer. J. Dis. Child* 133, 632-635.
- Moldawer, M., Zimmerman, S.J. & Collins, L.C. (1965) Incidence of osteoporosis in elderly whites and elderly negroes. *JAMA* 194, 859-862.
- Nathorst Westfelt, J.A.R. (1982) Environmental factors in childhood accidents. A prospective study in Göteborg, Sweden. *Acta Paediatr. Scand., Suppl.* 291.
- Neer II, C.S. & Horwitz, B.S. (1965) Fractures of the proximal humeral epiphyseal plate. *Clin. Orthop.* 41, 24-31.

- Nilsson, B.E. (1969) Parity and osteoporosis. *Surg. Gynec. Obstet.* 129, 27-28.
- Nilsson, B.E. (1970) Conditions contributing to fracture of the femoral neck. *Acta Chir. Scand.* 136, 383-384.
- Nilsson, B.E. & Westlin, N.E. (1974) The bone mineral content in the forearm of women with Colles' fracture. *Acta. Orthop. Scand.* 45, 836-844.
- Nilsson, B.E. & Westlin, N.E. (1977) Bone mineral content and fragility fractures. *Clin. Orthop.* 125, 196-199.
- Padilla, E.R., Rohsenow, D.J. & Bergman, A.B. (1976) Predicting accident frequency in children. *Pediatrics* 58, 223-226.
- Palmertz, B. (1975) Diagnostiskt utbyte av akut skullröntgen vid trauma. *Läkartidn.* 72, 1673-1674.
- Panzner, R. (1966) Unfallhäufigkeit im Kindesalter. *Beitr. Orthop. Traum.* 13, 348-354.
- Pellerin, D., Rigault, P. & Fekete, Cl.-N. (1971) Aspects chirurgicaux des accidents de l'enfant: 13,433 cas. Expérience d'un grand centre hospitalier infantile urbain Clinique Chirurgicale des Enfants-Malades, Paris. *Rev. Pédiatr.* 7, 403-416.
- Peterson, C.A. & Peterson, H.A. (1972) Analysis of the incidence of injuries to the epiphyseal growth plate. *J. Trauma* 12, 275-281.
- Pettersson, B. & Hügård, G. (1982) Barn i trafiken. Trafiksäkerhetsverket, Borlänge, Sweden.
- Reed, M.H. (1977) Fractures and dislocations of the extremities in children. *J. Trauma* 17, 351-354.
- Reiner, G., Deisenhammer, W., Opitz, A., Descovich, G. & Wagner, M. (1979) Unfallursachen und Verletzungsart im Kindesalter an einer Unfallklinik. *Pädiatrie und Pädologie* 14, 241-248.
- Sano, S. & Kitamura, M. (1979) *Popular Medicine* 89, 90-95.
- Shore, R.M., Chesney, R.W., Mazess, R.B., Rose, P.G. & Bargman, G.J. (1980) Bone mineral status in growth hormone deficiency. *J. Pediatr.* 96, 393-396.
- Shore, R.M., Chesney, R.W., Mazess, R.B., Rose, P.G. & Bargman, G. J. (1981) Osteopenia in juvenile diabetes. *Calcif. Tiss. Int.* 33, 455-457.
- Shore, R.M., Chesney, R.W., Mazess, R.B. et al. (1983) Skeletal demineralization in Turner's syndrome. *Calcif. Tiss. Int.* In

press.

- Sibert, J.R., Maddocks, G.B. & Brown, B.M. (1981) Childhood accidents - an endemic of epidemic proportions. *Arch. Dis. Child.* 56, 225-234.
- Stallones, R.A. & Corsa, Jr., L. (1961) Epidemiology of childhood accidents in two California counties. *Publ. Hlth. Rep.* 76, 25-36.
- Vahvanen, V. & Aalto, K. (1980) Classification of ankle fractures in children. *Arch. Orthop. Traumat. Surg.* 97, 1-5.
- Wallberg, K. (1957) Barn i trafiken. En undersökning av barnens trafikolycksfall. *Statens Trafiksäkerhetsråd, Stockholm, Meddelande 6.*
- Wong, P.C.N. (1965) A comparative epidemiologic study of fractures among Indian, Malay and Swedish children. *Med. J. Malaya* 20, 132-143.
- Wong, P.C.N. (1966) Fracture epidemiology in a mixed Southeastern Asian community (Singapore). *Clin. Orthop.* 45, 55-61.
- Vose, G.D. & Lockwood, R.M. (1965) Femoral neck fracturing - its relationship to radiographic bone density. *J. Geront.* 20. 300-305.

APPENDIX

Table A:I. The number of child risk years per age group 1975 - 1979.

Age	Boys	Girls	Total
0-2	18,385	17,457	35,842
3-4	12,183	11,528	23,711
5-6	12,225	11,330	23,555
7-8	12,377	11,757	24,134
9-10	13,177	12,597	25,774
11-12	14,377	13,677	28,054
13-14	14,543	14,073	28,616
15-16	14,463	14,118	28,581
Total	111,730	106,537	218,267

Table A:II. Data collection and classification.

Date of birth
 Date of fracture
 Type of fracture
 Skull
 Facial bones
 Cervical spine
 Thoracic spine
 Lumbar spine
 Sternum
 Sacrum
 Other pelvic bones
 Scapula
 Clavicle
 Proximal end of the humerus, epiphyseolysis included
 Humerus, diaphysis
 Supracondylar region of the humerus
 Lateral humerus condyle
 Medial humerus condyle
 Medial humerus epicondyle
 Y-shaped or comminuted, condyle
 Epiphyseolysis of the proximal end of the radius
 Neck of the radius
 Radius, capitulum
 Olecranon
 Combinations of elbow fractures
 Radius-ulna, diaphysis
 Radius, diaphysis only
 Ulna, diaphysis only
 Monteggia fracture
 Galeazzi fracture
 Radius + ulna, distal
 Radius, distal
 Epiphyseolysis of the distal radius
 Ulna, distal, epiphyseolysis included.
 Scaphoid
 Other carpal or metacarpal bones
 Fracture or epiphyseolysis of the phalanges of the hand

Cervical femoral
Trochanteric femoral
Subtrochanteric femoral
Femur, diaphysis
Supracondylar region of the femur
Medial femur condyle
Lateral femur condyle
Y-shaped or comminuted, distal femur
Epiphyseolysis of the distal femur
Patella
Medial tibial condyle
Lateral tibial condyle
Both tibial condyles
Tibial spine
Epiphyseolysis of proximal tibia
Proximal tibia
Tibial tuberosity
Tibia, shaft (with or without injury of the fibula)
Proximal end or the shaft of the fibula
Epiphyseolysis of the distal tibia
Lateral malleolus
Epiphyseolysis of the lateral malleolus
Medial malleolus
Bimalleolar
Other fractures of the ankle joint
Os calcis
Talus
Other fractures of the tarsus or metatarsus
Phalanges of the foot

Severity of trauma

Slight
Moderate
Severe
Not classified
Unknown

Type of trauma

- Falling in the same level or similar trauma
- Falling from height
- Caught or squeezed
- Bites
- Blows
- Hit by moving object
- Birth injury
- Battered child
- Repeated minor trauma - stress fracture
- Not classified, unknown

Environmental factor

- Home
- Nursing home, day-care centre
- School
 - School yard
 - School sports
- Play activities
 - Play-ground
 - Play-ground fixture such as swings and slides
 - Sleigh
 - Pedal car
 - Tricycle
 - Skateboard
 - Roller-skates
 - Play-ground scuffles
 - Other play accidents
- Unknown

Traffic

- Bicycle injuries (single injuries, falling off bicycle, collision with pedestrians, other cyclists or unmoving objects, passenger on a bicycle, collision of bicycles)
- Cyclist hit by car or other heavier vehicle
- Caught in bicycle wheel (spoke injuries)
- Pedestrian hit by bicycle or moped
- Pedestrian hit by car, bus, motor-cycle or streetcar
- Passenger or driver of car or tractor

Passenger or driver of moped or motor-cycle in single accidents or collision with pedestrian, bicycle or unmoving object

Passenger or driver of moped or motor-cycle in collision with car, bus or streetcar

Other traffic accidents

Labour accidents

Falling

Injuries from tools, tractor, harvesting machine, chain saw or other machinery

Other labour accidents

Sport injuries

Ball sports

Skiing

Ice-hockey - skating

Sports related to water

Gymnastics

Contact sports such as wrestling, karate, judo and boxing

Falling from horse

Horse-bites or kicks

Other sport injuries

Treatment

Not treated

No reduction (with or without fixation)

Closed reduction and external fixation including percutaneous pin-fixation

Open reduction with internal or external fixation

Closed reduction + osteosynthesis

Traction

Other types of treatment

Concomitant disease

Skeletal disorder such as osteogenesis imperfecta

Local skeletal disorder - "pathological" fracture

Neurological disorder

General joint disorder

Renal osteodystrophy

Endocrine disorder

Nutritional defect - malabsorption

Congenital malformation syndrome

Mental retardation

Diabetes

Leukemia

Other malignancy

Other diseases

Unknown

Accumulated number of fractures per individual

Fracture on the same site within a year

Table A:III. DISTAL END OF THE FOREARM 1975 - 1979 (physeal fractures excluded). Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	14	7.6	14	8.0
3-4	18	14.8	20	17.4
5-6	50	40.9	40	35.3
7-8	60	48.5	53	45.1
9-10	88	66.8	82	65.1
11-12	111	77.2	86	62.9
13-14	142	97.6	55	39.1
15-16	99	68.5	21	14.9

Table A:IV. PHYSEAL FRACTURES OF THE DISTAL END OF THE RADIUS 1975 - 1979. Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	0	0	0	0
3-4	0	0	0	0
5-6	3	2.5	2	1.8
7-8	5	4.0	2	1.7
9-10	7	5.3	10	7.9
11-12	10	7.0	7	5.1
13-14	22	15.1	6	4.3
15-16	14	9.7	4	2.8

Table A:V. PHALANGES OF THE HAND 1975 - 1979.
Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	6	3.3	9	5.2
3-4	16	13.1	16	13.9
5-6	23	18.8	16	14.1
7-8	27	21.8	25	21.3
9-10	52	39.5	47	37.3
11-12	94	65.4	96	70.2
13-14	151	103.8	96	68.2
15-16	129	89.2	70	49.6

Table A:VI. CARPAL-METACARPAL FRACTURES 1975 - 1979 (scaphoid excluded).
Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	2	1.1	0	0
3-4	8	6.6	2	1.7
5-6	7	5.7	0	0
7-8	12	9.7	6	5.1
9-10	27	20.5	4	3.2
11-12	69	48.0	9	6.6
13-14	105	72.2	10	7.1
15-16	108	74.7	14	9.9

Table A:VII. CLAVICLE 1975 - 1979.

Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	33	18.0	38	21.8
3-4	33	27.1	38	33.0
5-6	36	29.5	25	22.1
7-8	27	21.8	5	4.3
9-10	15	11.4	11	8.7
11-12	17	11.8	10	7.3
13-14	32	22.0	17	12.1
15-16	29	20.1	7	5.0

Table A:VIII. ANKLE 1975 - 1979.

Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	1	0.5	0	0
3-4	6	4.9	1	0.9
5-6	5	4.1	10	8.8
7-8	6	4.9	14	11.9
9-10	17	12.9	19	15.1
11-12	20	13.9	31	22.7
13-14	33	22.7	22	15.6
15-16	42	29.0	28	19.8

Table A:IX. TIBIA DIAPHYSIS 1975 - 1979.
Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	15	8.2	5	2.9
3-4	21	17.2	8	6.9
5-6	23	18.8	14	12.4
7-8	18	14.5	6	5.1
9-10	22	16.7	8	6.4
11-12	10	7.0	9	6.6
13-14	25	17.2	14	10.0
15-16	26	18.0	9	6.4

Table A:X. TARSAL-METATARSAL FRACTURES 1975 - 1979 (talus, os calcis excluded). Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	4	2.2	7	4.0
3-4	16	13.1	7	6.1
5-6	16	13.1	5	4.4
7-8	10	8.1	9	7.7
9-10	7	5.3	14	11.1
11-12	18	12.5	29	21.2
13-14	34	23.4	10	7.1
15-16	17	11.8	6	4.3

Table A:XI. PHALANGES OF THE FOOT 1975 - 1979.
Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	2	1.1	3	1.7
3-4	2	1.6	2	1.7
5-6	4	3.3	5	4.4
7-8	9	7.3	4	3.4
9-10	12	9.1	9	7.1
11-12	18	12.5	16	11.7
13-14	29	19.9	17	12.1
15-16	19	13.1	7	5.0

Table A:XII. RADIUS-ULNA DIAPHYSIS 1975 - 1979.
Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	6	3.3	3	1.7
3-4	9	7.4	6	5.2
5-6	15	12.3	13	11.5
7-8	16	12.9	9	7.7
9-10	10	7.6	6	4.8
11-12	15	10.4	6	4.4
13-14	21	14.4	7	5.0
15-16	14	9.7	1	0.7

Table A:XIII. SUPRACONDYLAR REGION OF THE HUMERUS 1975 - 1979.
Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	3	1.6	2	1.2
3-4	8	6.6	13	11.3
5-6	24	19.6	23	20.3
7-8	17	13.7	7	6.0
9-10	17	12.9	18	14.3
11-12	9	6.3	3	2.2
13-14	5	3.4	0	0
15-16	1	0.7	0	0

Table A:XIV. PROXIMAL END OF THE HUMERUS 1975 - 1979.
Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	0	0	2	1.2
3-4	1	0.8	2	1.7
5-6	2	1.6	1	0.9
7-8	6	4.9	4	3.4
9-10	4	3.0	15	11.9
11-12	6	4.2	20	14.6
13-14	12	8.3	18	12.8
15-16	6	4.2	2	1.4

Table A:XV. SKULL 1975 - 1979.
Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	23	12.5	16	9.2
3-4	6	4.9	3	2.6
5-6	5	4.1	0	0
7-8	4	3.2	2	1.7
9-10	4	3.0	2	1.6
11-12	5	3.5	1	0.7
13-14	5	2.1	1	0.7
15-16	3	2.1	5	3.5

Table A:XVI. FEMUR DIAPHYSIS 1975 - 1979.
Age, number of fractures, annual incidence per 10,000.

Age	Boys		Girls	
	Number	Incidence	Number	Incidence
0-2	12	6.5	5	2.9
3-4	12	9.6	1	0.9
5-6	8	6.5	3	2.7
7-8	7	5.7	6	5.1
9-10	3	2.3	0	0
11-12	1	0.7	2	1.5
13-14	2	1.4	4	2.8
15-16	7	4.8	2	1.4