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## Original Article

# Increasing incidence of fracture and its sex difference in school children: 20 year longitudinal study based on school health statistic in Japan

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## ABSTRACT

**Background:** Studies on the epidemiology of pediatric fractures have been scarce in recent years although fractures are very common in childhood. Boys have a higher incidence of fractures than girls. Currently, societal trends have seemed to influence the difference in activity patterns between boys and girls, but the sex difference regarding longitudinal changes in fracture incidence is not well known.

**Methods:** We analyzed the school accident report in Niigata city, Japan and compared the incidence of fractures in elementary and junior high school students and the sex-related risk ratio between two 9-year periods separated by 20 years from their start and end points (1999–2007 and 1979–1987).

**Results:** The study included 383,273 students from 1999 to 2007 and 561,109 students from 1979 to 1987. Comparing these periods, the fracture incidence increased significantly by 2.4 times in boys vs 2.1 times in girls from elementary school and by 2.2 times in boys vs 2.9 times in girls from junior high school (all  $p < 0.001$ ). The sex-related risk ratio of boys to girls increased significantly from 1.47 to 1.64 in elementary school students. In contrast, it decreased significantly from 3.29 to 2.52 in junior high school students and the change was markedly significant because of the drastic increase in fracture incidence in junior high school girls.

**Conclusions:** The reasons proposed for the increase in schoolchildren's fractures were an improvement in diagnosis owing to social background and increased participation in sports activities despite the general decline in children's physical fitness and exercise ability. In junior high school girls, in particular, there was an increase in fracture risk due to increased participation in sports activities.

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## 1. Introduction

Injuries are very common in childhood. About 25% of children are injured each year [1,2] and fractures account for 10–25% of childhood injuries [3]. In spite of this frequency, data on the

epidemiology of pediatric fractures are scarce. Some studies in the United States and Japan showed an increase in distal forearm fractures in children [4,5]. Regarding whole fractures, Landin reported that their incidence almost doubled between the 1950s and 1970s in children of Malmö, Sweden [6]. Thereafter, it slightly declined in that area in the 1990s [7]. However, there have been comparatively few recent studies about the epidemiology of fractures in children [2,8,9], and in particular, there have been few longitudinal reports in Asia. Additionally, boys have a higher incidence of fractures than girls; however, the sex difference regarding the longitudinal changes in fracture incidence is not well known.

The purpose of this study was to analyze the incidence of fractures and its sex difference in Japanese schoolchildren comparing two periods using the available data.

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## 2. Materials and methods

### 2.1. Study population

The subjects of this study were elementary and junior high school student of Niigata city. Niigata city is located at 37°54'N, 139°1'E in Niigata Prefecture, Japan. Niigata city is the capital of the prefecture and is located in the center of the west coast of the Japanese archipelago. Education through junior high school is compulsory in Japan. All children from age 6 to 14 years enroll in one of the schools in the area. In the Japanese education system, elementary school lasts 6 years from April of age 6 years and junior high school lasts 3 years from April of age 12 years. The study period in focus was from 1999 to 2007. To compare with past data, we reviewed previously published data for 1975–1989 [10,11]. The number of students in elementary and junior high school from previous study is shown in Fig. 1A. In 1975, the number was 39,100 and 16,485 in elementary and junior high school, respectively. It peaked in 1982 and 1987 for elementary and junior high school, respectively. Thereafter, it decreased finally in 1989 to 37,106 and 22,065 for elementary and junior high school, respectively. The annual incidences (per 100 students) during this period are shown in Fig. 2A. The study area was not changed in the study including the previous data.

### 2.2. School accident report

The school accident report includes all student-related traumatic accidents in school. This report is submitted by the school nurse of each school to the Board of Education every year.

Traumatic accidents in this report include not only trauma during class, but also all school-related activities; general events, sports, and extracurricular lessons. This report also includes accidents on the way to and from school. We surveyed all reports containing fractures from 1999 to 2007.

The study was approved by the Ethics Committee of our University School of Medicine (receipt number 986). The personal information of the report was encrypted as a code number and care is taken not to identify individuals. The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

### 2.3. Statistic methods

The annual incidence (per 100 students) was calculated by the number of students of each year. In order to know the difference from the past, we used data from 1979 to 1987 (gray in Fig. 1A and B), which is 20 years before the focus period (1999–2007) in this study, and compared the incidence (per 100 students). The chi-square test was used for the comparison. Sex-related risk ratio, which was defined as the ratio of incidence in boys compared to girls, was expressed as relative risk and 95% confidence intervals. P-values < 0.05 were regarded as statistically significant. Data analyses were performed using SPSS version 22.0 (IBM Corp., N.Y, USA).

## 3. Result

From 1999 to 2007 Niigata City had a total of 383,272 students including 252,693 (129,674 boys and 123,019 girls) in elementary

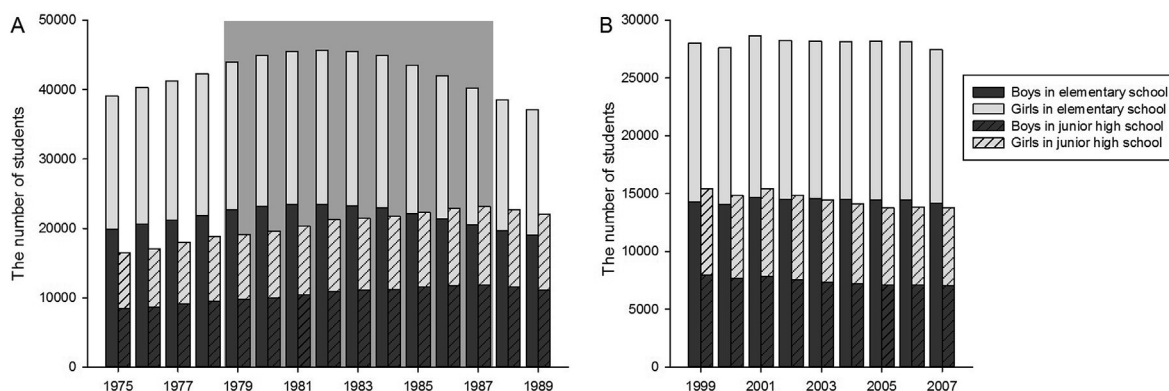


Fig. 1. The number of elementary and junior high school students. A: 1975–1989. 1979–1997 (gray) was used for comparison. B: 1999–2007.

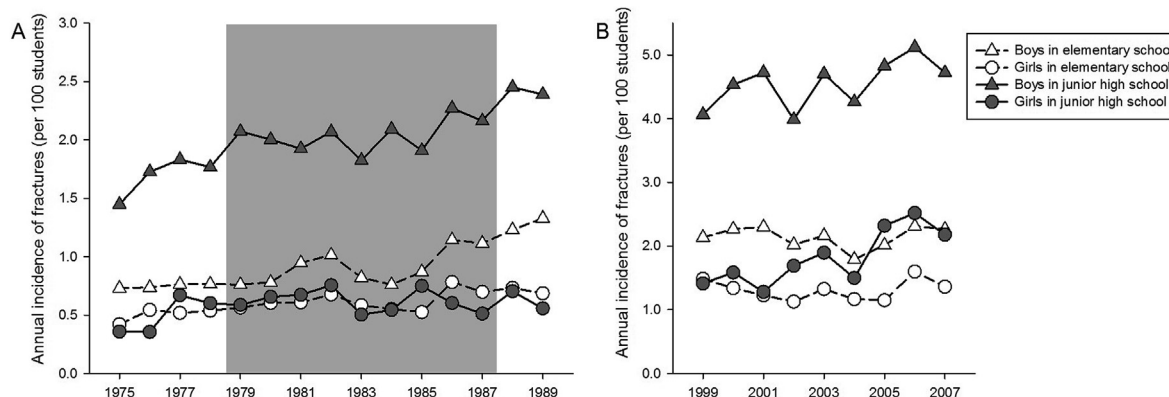


Fig. 2. The annual incidence of fractures in both sexes in elementary and junior high school. The annual incidence is expressed as the number of cases per 100 students. A: 1975–1989. 1979–1997 (gray) was used for comparison. B: 1999–2007.

school and 130,580 (66,865 boys and 63,715 girls) in junior high school. In 1999, there were 43,459 students including 28,014 elementary school students and 15,445 junior high school students. In 2007, there were 41,226 students including 27,451 elementary school students and 13,775 junior high school students. The number of students in each year is shown in Fig. 1A. There were 8602 school accident reports including fractures during this period. Thirty-seven reports were excluded from analysis because the age or sex of the student was unfilled in the report. Therefore, 8565 reports including 4397 in elementary school and 4168 junior high school were analyzed.

Fig. 3 shows the type of activity students were engaged in when fractures occurred. In elementary school students, fractures most commonly occurred in both genders during recess and break time (47.0% of boys and 37.8% of girls). 22.2% of boys and 26.9% of girls sustained fractures during physical education (PE). In junior high school students, nearly half (boys: 45.3%, girls 49.1%) sustained fractures in sports clubs. Of the rest, fractures occurred in 31.6% of boys and 22.9% of girls in PE and 22.8% of boys and 10.2% of girls during recess and break time. In total, fractures were reported in 31.0%, 25.4% and 24.6% of elementary and junior high school students, during recess and break time, in sports clubs and during PE, respectively.

The annual incidence rates per 100 for each year are shown in Fig. 2A. In the 9 years, the annual incidence for elementary school boys and girls ranged from 1.79 to 2.31 and from 1.13 to 1.60, respectively. For junior high school boys and girls, the value ranged from 3.99 to 5.12, and from 1.28 to 2.52, respectively. For both elementary and junior high school students, boys always had a higher incidence than girls.

The number of students and the annual incidence from 1979 to 1987 is shown in gray in Figs. 1B and 2B. The total number of students in this period was 396,119 and 191,794 in elementary and junior high school, respectively. In the 9 years, the annual incidence for elementary school boys and girls ranged from 0.76 to 1.14 and from 0.53 to 0.78, respectively. For junior high school boys and girls, the value ranged from 1.83 to 2.27, and from 0.50 to 0.76, respectively. For both elementary and junior high school students, boys always had a higher incidence than girls.

The comparison of the incidence and the sex risk ratio between the two periods (1999–2007 and 1979–1987) is shown in Table 1. The incidence for boys was higher than that for girls for both periods (both  $p < 0.001$ ). For elementary school, the incidence increased significantly by 2.4 times in boys and 2.1 times in girls (both  $p < 0.001$ ). The sex-related risk ratio for boys to girls increased significantly from 1.47 to 1.63. For junior high school students, the incidence increased significantly by 2.2 times in boys and, 2.9 times in girls (both  $p < 0.001$ ). The sex-related risk ratio significantly decreased from 3.29 to 2.52 and the change was bigger than in elementary school students.

#### 4. Discussion

Little epidemiological information is available for child fractures in Japan. This study is the first longitudinal observational comparison study that was designed to supply essential information of child whole fractures in the Japanese population.

This study showed an increase in the incidence of fractures in schoolchildren by comparing two 9-year periods separated by 20

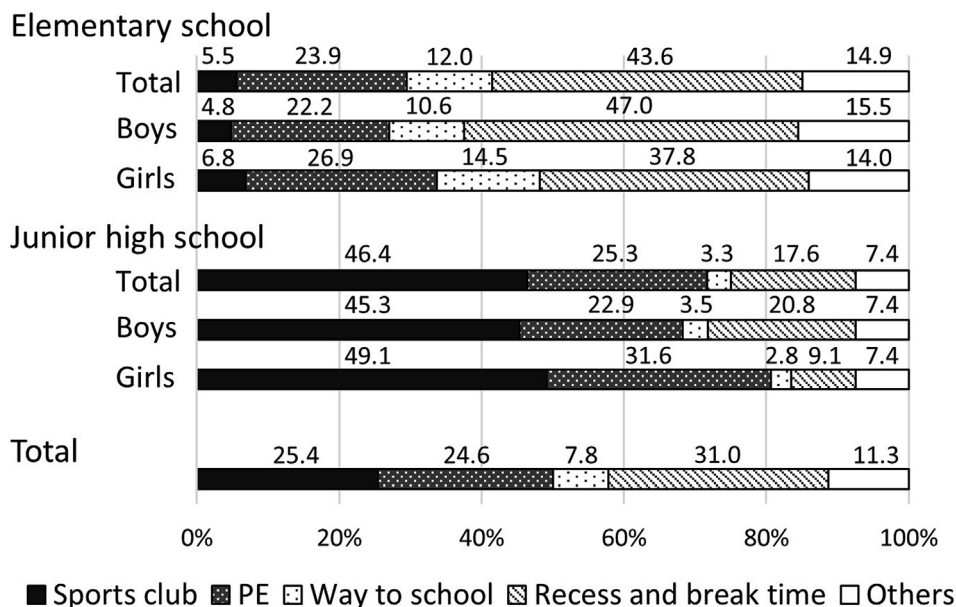
**Table 1**

Comparison of incidence of fractures and sex-related risk ratio between two 9-year periods. (1999–2007 and 1979–1987).

	Case/cumulative total number	Incidence (100 students)	Sex related risk ratio (95% CI)
Elementary school			
1999–2007	Boys 2785/129,674	0.24	1.63 (1.57–1.70)
	Girls 1612/123,019	0.15	
1979–1987	Boys 1846/203,052	0.10	1.47 (1.40–1.54)
	Girls 1197/193,061	0.07	
Junior high school			
1999–2007	Boys 3024/66,865	0.50	2.52 (2.43–2.61)
	Girls 1144/63,715	0.20	
1979–1987	Boys 2010/98,531	0.23	3.29 (3.15–3.44)
	Girls 578/93,229	0.07	

Sex-related risk ratio was defined as the ratio of incidence in boys compared to girls. The incidence for boys was higher than that for girls in both periods for elementary school and junior high school students ( $p < 0.001$ ).

The incidence from 1999 to 2007 was higher than that from 1979 to 1987 in both sexes for elementary school and junior high school students ( $p < 0.001$ ).



**Fig. 3.** The type of activity that students were engaged in when fractures occurred. PE: physical education.

years using school health statistics data. The incidence more than doubled in both sexes of elementary school and junior high school students. The population of this study was the number of students in the schools and it is considered that the characteristics of this population are not markedly different from that of the city population because children in the city belong to any school in their area. Several previous studies have reported an increase in the incidence of child fractures, however, the study design such as fracture type, data collection method, observation period, or the base population differed from each other. Khosla et al. [4] reported an increase in distal forearm fractures in Rochester, Minnesota with medical records based on their population, comparing four periods within 30 years from 1969 to 2001. In Japan, Hagino et al. [5] reported the incidence of distal forearm fractures in the Tottori prefecture using the hospital records of clinics and hospitals in their prefecture, which may have treated patients with fractures, based on their population. Comparing the data of 3 periods from 1922 to 1995, they found that the fracture incidence for boys (7–12 years of age) had increased. For whole fractures, Landin [6] reported the epidemiology of fractures in children 16 years or less in Malmö, Sweden and the incidence of fractures almost doubled between the 1950s and 1970s. The incidence was calculated from the registry data of the department of diagnostic radiology and the emergency rooms of the general hospital of their population. Torii [12] reported that the incidence of fractures in elementary and junior high school students almost doubled in 30 years from 1970 in Japan; the study was based on Japan nationwide school health insurance statistics. Moreover, the annual incidence in his study was 0.7 and 1.3 per 100 students for elementary and junior high school students, respectively, in 1975, which then consistently increased reaching 1.3 and 2.4, respectively, in 2000. It is unsurprising that these incidences were always between the boy and girl incidences in the same year of this study.

With regard to the cause of the increase in fractures, Khosla and Hagino [4,5] suggested the association between bone porosity caused by growth spurts or nutrition in the increase of distal forearm fracture. These are child risk factors. However, Landin showed the increase was greatest for undisplaced fractures that did not require reduction and indicated that such fractures may have been neglected and undiagnosed during the early part of the time period of his study. He suggested that the parents at that time may have been less inclined to seek medical advice, and the change of the medical system of his country, which reduced payment of radiography examination in fractures, may have increased the frequency of the examination and detection of fractures [6]. In Japan, the government has continued to enrich school safety management system via several laws of school health such as revisions of the School Health Law of 1978 and the establishment of the Japan School Safety Association in 1960. However, an increasing number of school accident related lawsuits have arisen [13]. In addition, the number of birth in Japan continues to decrease with a peak at 1973 [14]. Following this decrease, the population of schoolchildren in this study also began to decrease after 1982 and 1987 in elementary school and junior high school, respectively. Because of the decreasing birthrate in Japan, parents and schools have become more careful regarding childcare and this may be the cause of the improved diagnosis of minor fractures. Tiderius et al. [7] found a slight decline in the incidence of fractures between 1993 and 1994 in the follow-up report of Malmö. They linked this to a general safety awareness that had developed in Sweden. However, they also indicated that the spontaneous playing activities of children had decreased considerably and children in the 1990s were less physically active than in previous years. The decline of physical fitness of children was also noted in Japan. The Ministry of Education, Culture, Sports, Science, and Technology (MEXT) has

conducted an assessment of physical strength and the ability to exercise every year since 1964. The results of current assessment have indicated that although there have been improvements in children's body size in terms of height and weight, their performance in tests of physical strength and the ability to exercise, such as the 50-m dash and softball throwing, is low compared with 1985 [15]. However, participation and the desire to participate in sports activities were high in children. Previously we reported the circumstances when fractures occurred from the school accident report in Niigata City, which was the exact same area of this study, of 1981, 1990, 1999 and 2008. During this time, 11.5% of all elementary and junior high school students sustained fractures in sports club in 1981 and increased to 13.9% in 1990. Then it continued to increase to 23.8% in 1999 and to 25.6% in 2008, which were start and end of this study period [11]. MEXT administered a nationwide sports survey to a sample of junior high school students in 1991, which was between the periods of focus in this study. From the results of the survey, when students were asked regarding the extent of their participation in sports activities outside of physical education classes, compulsory sports clubs, or school sporting events during the year, approximately 90% participated and 46.2% were engaged in sporting activities for three or more days a week. Furthermore, about 70% of students not participating in sports answered that they would like to do so in the future [16]. These surveys indicated many students participated in sports activities despite the decreased physical fitness and ability to exercise. This situation is considered as cause of the increase in fractures.

In this study, boys always had a higher incidence of fractures than girls in all study periods and junior high school boys had a particularly higher fracture incidence than girls. The predominance of fractures in boys is a common finding in the literature. Landin [6] showed that fractures were more common among boys in all age groups, fractures in boys became twice as common compared to girls. This was proposed to be due to the difference in activity patterns between boys and girls. In this study, fractures that occurred in recess and break time, a time of mainly spontaneous play activities, were higher in boys than in girls in both elementary and junior high school. This may be due to differences in activity patterns between boys and girls. Thus this difference should effect strongly in elementary school students who have many fractures in recess and break time.

The change in sex-related risk in elementary and junior high school students in both assessed periods contrasted with each other. In elementary school students, the risk ratio of boys against girls increased. In junior high school students, although the incidence of boys increased, that of girls increased markedly in 20 years. As a result, the sex-related risk notably decreased from 3.29 to 2.52. Even the change in annual incidence of junior high school girls during the 9 years from 1999 to 2007 (Fig. 2B) was about the same level as for elementary school girls in the early part of the period, and continued increasing, finally reaching the same level as that of elementary school boys in the later period. Although the increase of risk in elementary school students can be attributed to the improvement in the diagnosis of fractures because, originally, boys were more prone to have fractures, the decrease in risk in junior high students needs another reason. According to the epidemiology study by Malmö in 1993–4, distal forearm fractures in girls were exceptionally increased and this was attributed to the increasing incidence of the fractures and the increase in girl participation in sports and recreational activities, comparable to boy rates [7]. Distal forearm fractures and finger phalanges fractures are the most common adolescent sports-related fractures [9,17]. Importantly, competitive sports are predominantly commenced in junior high school. Additionally in this study, fractures in junior high school girls most frequently occurred in sports

club, and the percentage was higher than in boys. Therefore, increased participation in sports activities seems to greatly influence injury risk in junior high school girls.

This study has several limitations. First, the subjects of this study were drawn from a Japanese provincial urban city and were not nationally representative. However, there was no inconsistency with population dynamics in Japan and the results of a previous nationwide study. Second, since this study was based on school accident reports, we were unable to ascertain the number of fractures that may have occurred other than those reported by the school management. Moreover, the severity and the treatment modalities for the fractures were not obtained.

In conclusion, we analyzed the incidence of fractures in Japanese schoolchildren from school accident reports comparing two 9-year periods. The incidence increased more than two-fold in both sexes of elementary and junior high school, and this was attributed to improved diagnosis due to increased societal awareness of fractures and increased participation in sports activities despite the decline of children's physical fitness and exercise ability. In junior high school girls, in particular, the increase in injury risk was strongly attributed to increased participation in sports activities.

### Conflict of interest

All authors have no conflicts of interest.

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