



# Epidemiology of pediatric fractures before versus during the coronavirus disease 2019 pandemic

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Several studies have reported changes in the prevalence of childhood fractures between the prepandemic and coronavirus disease 2019 pandemic periods considering the overall decrease in activity during the latter. This review aimed to organize and summarize the global trends in pediatric fracture incidence. Our findings should help predict fracture patterns in the postpandemic period by identifying changes in the past and present, thus aiding patient management.

**Keywords:** COVID-19, Orthopedics, Pediatrics, Fractures, Sports injuries

## Key message

- The novel coronavirus disease 2019 (COVID-19) was first reported in December 2019 as a cluster outbreak in Wuhan, since then, national lockdowns have included school closures, stay-at-home orders.
- The characteristics of adolescent fractures were often related to physical activity such as sports-related injury.
- During the COVID-19 pandemic, both in the East and the West, the incidence of fractures in children and adolescents is showing a decreasing trend worldwide.
- Fractures in children and adolescents were significantly reduced in the proportion of relatively low-energy damage, and the incidence of fractures in adolescents with greater activity compared to children was reduced.
- If COVID-19 pandemic ends, normal academic and sports activities increase due to the easing of lockdown policies, the number of trauma patients related to increased activity may increase rapidly, and clinics should prepare for this change.

## Introduction

Pediatric injuries account for a large proportion of emergency and orthopedic outpatient cases. The rate of childhood fractures

reportedly ranges from 12.0 to 36.1/1000 per year.<sup>1)</sup> The lifetime risk of sustaining a fracture for boys aged 0–16 years is reportedly 42%–64%, while that for girls is 27%–40%.<sup>2,3)</sup> In a study in Sweden, the overall annual incidence of fractures was 257 per 10,000 children in boys, 165 per 10,000 in girls, and 212 per 10,000 overall.<sup>2)</sup> Pediatric fractures constitute approximately 25% of all pediatric injuries.<sup>4)</sup>

The novel coronavirus disease 2019 (COVID-19) was first reported in December 2019 as a cluster outbreak in Wuhan, China.<sup>5)</sup> On March 23, 2020, UK Prime Minister Boris Johnson announced a national lockdown.<sup>6)</sup> Since then, national lockdowns have included school closures, stay-at-home orders, and business closures in an effort to reduce health care system strain.<sup>7)</sup>

This study aimed to investigate changes in the epidemiology of pediatric fractures before versus during the COVID-19 pandemic to clarify whether they are related to changes in activity patterns.

## Common characteristics of pediatric fractures prior to the COVID-19 pandemic

Fracture of the distal radius, the most common fracture in children, accounts for 25%–43% of all fractures, followed by those of the fingers and carpal bones.<sup>1,8–11)</sup> Overall, fractures of the upper limb account for two-thirds of all childhood fractures, whereas lower-limb fractures account for approximately one-third.<sup>12–14)</sup> Joeris et al.<sup>13)</sup> reported that forearm fractures were significantly more frequent in school-aged children (65%) and adolescents (63%). Randsborg et al.,<sup>12)</sup> in their series of 1,403 fractures in children younger than 16 years, noted that distal radial fractures were the most common injury, possibly due to snowboarding. Sex-based differences in sports injury rates can be attributed to participation rates or mechanics of movement.<sup>15–17)</sup> Soccer was the most common injury-related activity (12.0%), most commonly resulting in fractures of the distal radius.<sup>12)</sup> However, snowboarding was associated with the highest fracture

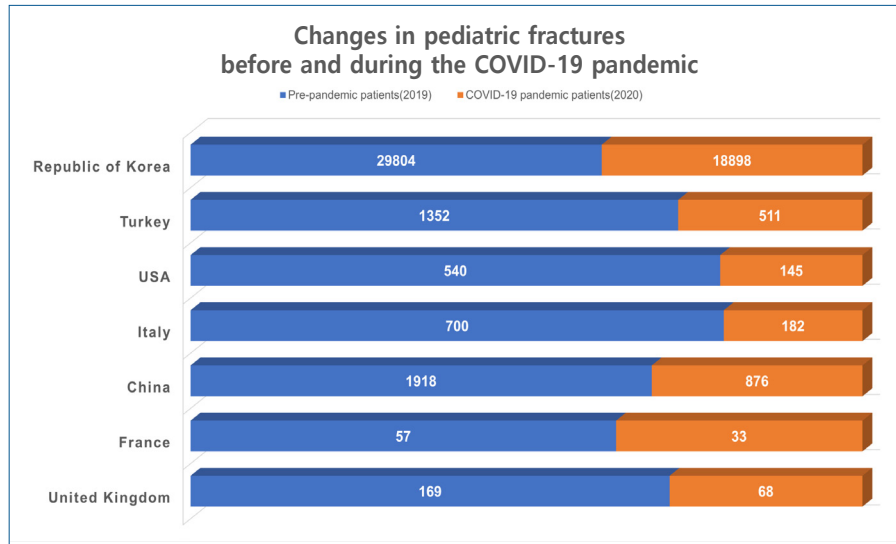
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Graphic abstract

rate (n=53; 1.9 fractures per 10,000 hours of exposure).<sup>12)</sup>

One study showed that boys (42%) had a higher rate than girls (27%) among 16-year-olds who experienced at least one fracture,<sup>18)</sup> while another study reported a peak incidence of fracture approximately 3 years earlier in girls than in boys (11 years vs. 14 years).<sup>9)</sup> Increased participation in both organized and informal sports and overall high levels of physical activity during adolescence have been suggested as reasons for the increased incidence of fractures among them.<sup>2,4,19,20)</sup> In particular, sex-based differences in the incidence of injuries may be explained by age-related changes in behavior, such as boys' participation in activities with increased physical risks.<sup>21)</sup>

### Changes in pediatric upper-extremity fracture patterns since COVID-19 outbreak

A retrospective review of all pediatric orthopedic patients admitted across the region during the lockdown in the United Kingdom<sup>22)</sup> (March 24 to May 10, 2020) and during the same period in 2019 reported 197 hospitalizations in 2019 and 132 hospitalizations during the pandemic, showing decreasing patient trends of 44 to 16 for wrist, 31 to 18 for forearm, and 24 to 16 for supracondylar fractures.

A prospective study in which pediatric traumatology emergency activity was compared between an 8-week lockdown for the COVID-19 epidemic in France,<sup>23)</sup> which included restricted travel and interrupted schooling and sports, and the same period in the previous 3 years. When only operated cases were considered, the number of upper-extremity fractures decreased from 61 to 39, humeral supracondylar fractures decreased from 18 to 16, and forearm distal-quarter fractures decreased from 20 to 7 compared with the control period.

Raitio et al.<sup>24)</sup> analyzed all five tertiary pediatric surgical/trauma centers in Finland. Operations in children aged > 16 years related

to fractures, appendicitis, and acute scrotum between March 1 and May 31, 2017 and the same period in 2020 were identified. The monthly frequencies of surgeries and trauma types were compared between 2017 and 2019 and 2020, and the number of surgeries for upper-extremity fractures decreased from 48 to 30.

We retrospectively compared children admitted to a tertiary pediatric hospital in China<sup>25)</sup> for traumatic injury between January 24 and March 10, 2020, to those admitted within the same period from 2017 to 2019. Children with fractures were compared in terms of etiology, fracture location, sex, and age to evaluate the effects of home confinement on the epidemiology of pediatric fractures during the COVID-19 pandemic. Compared with 2019, the number of humerus fractures decreased from 643 to 381, radius fractures from 275 to 119, ulna fractures from 272 to 133, clavicle fractures from 183 to 86, and phalanx fractures from 67 to 45; surgical rates changed from 14.00% to 12.07% for the humerus, 2.18% to 3.36% for the radius, 11.94% to 8.89% for the phalanx, and 1.10% to 3.01% for the ulna in 2020.

In a study by Gumina et al.,<sup>26)</sup> all skeletally immature (<18 years old) patients managed in the hospital's emergency unit between March 8, 2020 (first day of restrictions in Italy) and April 8, 2020, for shoulder and elbow trauma were retrospectively included and compared with patients of similar ages admitted within the same period in 2019. Compared to 2019, the number of cases of contusion decreased from 134 to 39, sprain from 87 to 7, dislocation from 3 to 0, physeal fracture from 14 to 1, and nonphyseal fracture from 89 to 21 in 2020.

This retrospective study compared acute fractures managed at a single level I pediatric trauma hospital in the United States during the COVID-19 pandemic (March 15 to April 15, 2020) with fractures managed in 2018 and 2019 at the same institution.<sup>27)</sup> Compared with before the pandemic, supracondylar upper-extremity fractures decreased from 81 to 23, medial epicondylar fractures from 15 to 3, lateral condylar fractures from 18 to 7, forearm shaft fractures from 40 to 15, and distal radius fractures

from 330 to 83 during the pandemic.

According to a report in Turkey,<sup>28)</sup> 2,960 patients had orthopedic fractures, comprising 552 patients during the pandemic (March 10 to July 1, 2020) and 1,158 and 1,250 control patients during the same periods in 2019 and 2018, respectively. Epidemiological characteristics, injury mechanisms, fracture locations, and treatment were analyzed and compared between these years for the adult and pediatric populations. Compared with 2019, pediatric orthopedic fracture cases decreased from 198 to 128 for the forearm, 58 to 35 for the humerus, and 35 to 19 for the clavicle in 2020.

Turgut et al.<sup>29)</sup> evaluated patients admitted with a new fracture during the pandemic (March 16 to May 22, 2020) in Turkey. The control group consisted of patients with new fractures admitted during the same periods in 2018 and 2019. Compared with 2019, the total number of fractures decreased from 967 to 350, including 100 to 15 for the finger, 316 to 88 for the distal radioulnar portion, 93 to 17 for the radioulnar shaft, 40 to 20 for the clavicle, and 177 to 66 for the distal humerus. The number of surgeries performed has decreased from 74 to 51.

A single-center retrospective study reported that the data were gathered from the pediatric emergency department of a pediatric hospital in Italy.<sup>30)</sup> Compared with 2019, the number of fractures decreased from 424 to 125, and the number of cases of sprain and blunt trauma decreased from 448 to 36. The number of cases was reduced from 276 to 97 for upper-limb fractures, 83 to 40 for the distal radius, 83 to 20 for the finger, 21 to 13 for the clavicle, 27 to 12 for the distal humerus, 20 to 4 for the metacarpus, 20 to 3 for the forearm, and 10 to 1 for the proximal humerus.

We analyzed patients from the Korean National Health Insurance System (NHIS) and the National Health Screening Program for Infants and Children (NHSPIC) databases. This dataset comprised children born in 2007–2010 in the Republic of Korea. According to these data, compared to 2019, the number of fractures decreased from 29804 to 18898, cases of shoulder and upper arm fractures decreased from 437 to 283, cases of forearm fractures decreased from 2,493 to 1923, and cases of wrist and hand fractures decreased from 1,216 to 763.

## Changes in pediatric lower-extremity fracture patterns after COVID-19 outbreak

According to a report in the United Kingdom,<sup>22)</sup> femur fractures decreased from 13 to 7. According to a study in France,<sup>23)</sup> the number of cases of lower-extremity fractures decreased from 21 to 13, femoral fractures from 5 to 8, tibial fractures from 7 to 1, and ankle fractures from 7 to 1. According to a report in Finland,<sup>24)</sup> lower-extremity surgeries decreased from 19 to 11.

Darling et al.<sup>31)</sup> investigated the number of pediatric lower-extremity surgeries and retrospectively analyzed data from August 28, 2019, to April 1, 2021. The number of patients decreased from 19 to 1 for the ankle, from 13 to 1 for the knee, from 7 to 2 for the femoral shaft, and from 4 to 0 for the foot; the

total number of surgeries decreased from 25 to 3.

A retrospective review in China<sup>25)</sup> reported that the number of tibial fractures decreased from 208 to 52, femoral from 192 to 32, and fibular from 78 to 28, while the surgery rate changed from 9.38% to 34.38% for the femur and from 6.73% to 5.77% for the tibia. Although the overall number of pediatric lower-extremity fracture patients decreased, the change in the number of injured patients requiring surgery for treatment did not change significantly, suggesting increased numbers of surgeries. Although the number of patients with fractures has decreased worldwide, the relatively increased proportion of patients requiring surgery suggests that the proportion of high-energy trauma cases has increased. As part of the policy to prevent COVID-19, school life-related activities have decreased, but movement using vehicles essential for daily life will be less affected, and the increase in surgery rates, such as for femoral fractures, a relatively high-energy trauma, is thought to be the cause.

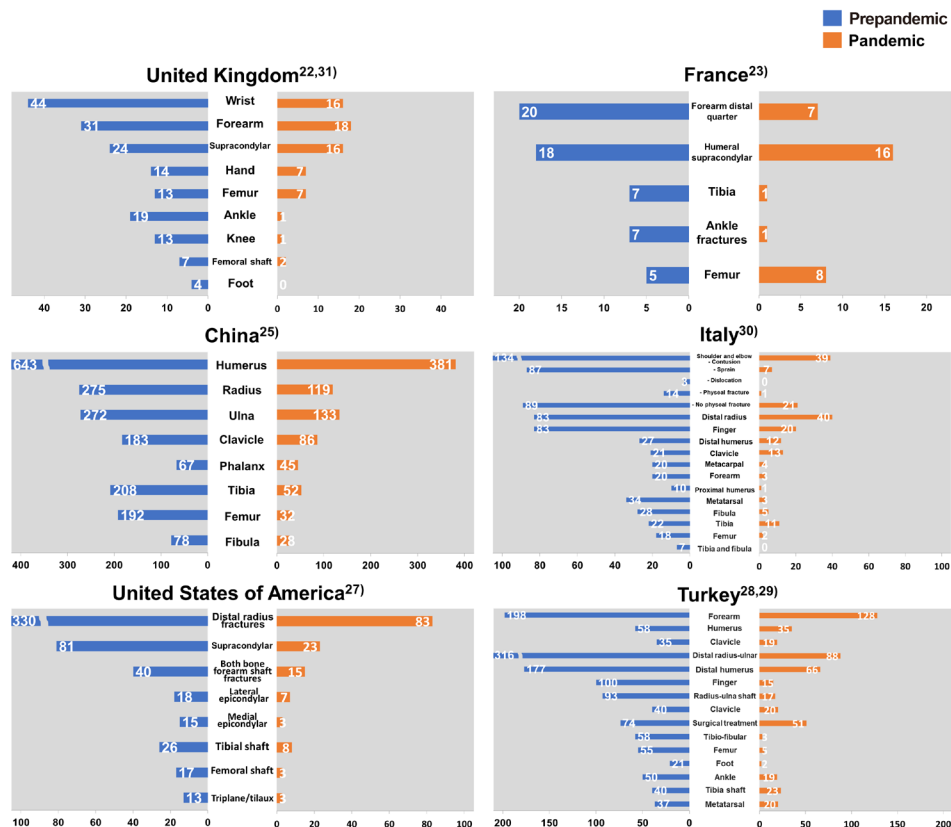
According to a report in the United States,<sup>27)</sup> the number of fracture cases decreased from 17 to 3 for the femoral shaft, 26 to 8 for the tibial shaft, and 13 to 3 for triplane/Tillaux. According to a report in Turkey,<sup>28)</sup> the number of fractures in the lower extremities decreased from 21 to 2 in the feet, 58 to 3 in the tibia and fibula, and 55 to 5 in the femur. A study in Turkey<sup>29)</sup> reported decreases in lower-extremity injury cases from 37 to 20 for metatarsal, 50 to 19 for ankle injury, and 40 to 23 for tibial shaft injury between the prepandemic and pandemic periods. According to a study in Italy,<sup>30)</sup> there were decreases in lower-extremity injuries from 22 to 11 for the tibia, 28 to 5 for the fibula, 34 to 3 for the metatarsals, 18 to 2 for the femur, and 7 to 0 for the tibia and fibula. The results are summarized in Fig. 1 and Table 1.

In the NHIS and NHSPIC databases mentioned above, compared to 2019, cases of femoral fracture decreased from 110 to 78, cases of lower leg fracture including the ankle decreased from 5,403 to 2,769, and cases of foot fracture decreased from 20,031 to 12,766.

## Changes in the mechanism of pediatric fracture after COVID-19 outbreak

According to a report in Turkey,<sup>28)</sup> falling from a standing height (or lower) and minor sports accidents (including ankle sprains) were considered low-energy traumas, whereas motor vehicle accidents, falls from a height, assaults, gunshots, and industrial and farm accidents were considered high-energy traumas. Compared to 2019, the number of low-energy trauma cases decreased from 220 to 51, while the number of high-energy trauma cases decreased from 158 to 16.

A study in the United States<sup>27)</sup> on pediatric fractures showed that the number of fractures decreased from 468 (32.5%) to 177 (57.8%) in the home, 266 (18.5%) to 74 (24.2%) in the public/street, 154 (10.7%) to 1 (0.3%) at school or daycare, 374 (26.0%) to 22 (7.2%) during sports, 129 (9.0%) to 16 (5.2%) on the playground, 352 (24.5%) to 65 (21.2%) from low-energy falls,



**Fig. 1.** This figure summarizes the global reporting trends on the change in the number of pediatric fracture patients after 2019, which is prepandemic, and 2020, which is during the pandemic. It can be seen that the number of patients in both upper and lower extremities decreased significantly worldwide, and the number of patients mainly related to sport injury decreased significantly. It is thought to be a change trend that occurred as the activity of the pediatric patient greatly decreased as a high-intensity prevention policy was implemented due to coronavirus disease 2019.<sup>22,23,25,27-31)</sup>

**Table 1. Summary of changes in pediatric lower & upper-extremity fracture patterns before and during coronavirus disease 2019 pandemic**

Author	Country	Upper extremity	Lower extremity
Baxter et al. <sup>22)</sup>	United Kingdom	Wrist: 44 → 16, forearm: 31 → 18, supracondylar: 24 → 16, hand: 14 → 7	Femur: 13 → 7
Bolzinger et al. <sup>23)</sup>	France	Total: 61 → 39, forearm distal quarter: 20 → 7 Humeral supracondylar: 18 → 16	Total: 21 → 13, tibia: 7 → 1, ankle fractures: 7 → 1. femur: 5 → 8
Darling et al. <sup>31)</sup>	United Kingdom		Total number of surgeries: 25 → 3, ankle: 19 → 1, knee 13 → 1, femoral shaft: 7 → 2, foot: 4 → 0
Li et al. <sup>25)</sup>	China	Humerus: 643 → 381, radius: 275 → 119, ulna: 272 → 133, clavicle: 183 → 86, phalanx: 67 → 45 Surgical rate -Humerus: 14% → 12.07%, radius: 2.18% → 3.36, phalanx: 11.94% → 8.89%, ulna: 1.10% → 3.01%	Tibia: 208 → 52, femur: 192 → 32, fibula: 78 → 28 Surgical rate -Femur: 9.38% → 34.38%, tibia: 6.73% → 5.77%
Gumina et al. <sup>26)</sup>	Italy	Shoulder and elbow -Contusion: 134 → 39, sprain: 87 → 7, dislocation: 3 → 0, physal fracture: 14 → 1, no physal fracture: 89 → 21	
Bram et al. <sup>27)</sup>	United States of America	Distal radius fractures: 330 → 83 Supracondylar: 81 → 23 Both bone forearm shaft fractures: 40 → 15 Lateral epicondylar: 18 → 7, medial epicondylar: 15 → 3	Tibial shaft: 26 → 8, femoral shaft: 17 → 3, triplane/tilaux: 13 → 3
Oguzkaya et al. <sup>28)</sup>	Turkey	Forearm: 198 → 128, humerus: 58 → 35, clavicle: 35 → 19	Tibio-fibular: 58 → 3, femur: 55 → 5, foot: 21 → 2
Turgut et al. <sup>29)</sup>	Turkey	Distal radius-ulnar: 316 → 88, distal humerus: 177 → 66, finger: 100 → 15, radius-ulna shaft: 93 → 17, clavicle: 40 → 20, surgical treatment: 74 → 51	Ankle: 50 → 19, tibia shaft: 40 → 23, metatarsal: 37 → 20
Ruzzini et al. <sup>30)</sup>	Italy	Total case: 276 → 97, distal radius: 83 → 40, finger: 83 → 20, distal humerus: 27 → 12, clavicle: 21 → 13, metacarpal: 20 → 4, forearm: 20 → 3, proximal humerus: 10 → 1	Metatarsal: 34 → 3, fibula: 28 → 5, tibia: 22 → 11, femur: 18 → 2, tibia and fibula: 7 → 0

312 (21.7%) to 103 (33.7%) from high-energy falls, 26 (1.8%) to 16 (5.2%) from motor vehicle accidents, 118 (8.2%) to 56 (18.3%) related to body-powered vehicles, and 243 (16.9%) to 42 (13.7%) from direct blows. The overall number of patients with fractures decreased, but the proportion changed as the fracture site changed.

A study from the United Kingdom<sup>22)</sup> of causes of pediatric trauma reported a decreased number of cases from 82 (34.2%) to 5 (4.6%) for sports, 42 (17.5%) to 24 (21.8%) for falls from standing, and 19 (7.9%) to 22 (20.0%) for bike/scooter/rollerblades in 2019 versus the pandemic period.

According to a report in Italy,<sup>30)</sup> in 2020, 143 trauma cases (82.6%) occurred in the home, 9 (10.9%) occurred on the street (riding bikes or skates), 9 (5.2%) were sports-related, and 2 (1.1%) occurred at the playground. In 2019, 294 trauma cases (32.3%) occurred in the home, 316 (34.7%) were sports-related, 147 (16.1%) occurred at school, 121 (13.3%) occurred at the playground, 15 (1.6%) occurred while playing, bicycling, or skating, 1 (0.1%) occurred due to a skiing accident, and 15 (1.6%) occurred due to car accidents. The results are summarized in Fig. 2 and Table 2.

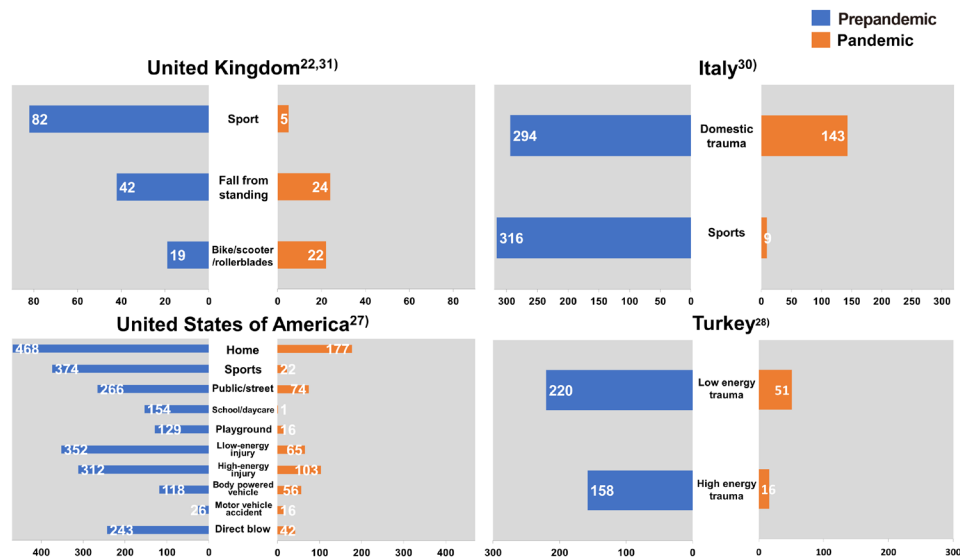


Fig. 2. Changes in the number of pediatric fracture patients worldwide according to injury mechanism and location at the time of injury comparing 2019 and 2020. Although the number of patients decreased in all injury mechanisms and locations, sport injuries were significantly reduced. For the same reason as Fig. 1, it is thought to be an impact from the coronavirus disease 2019 prevention policy.<sup>22,27,28,30,31)</sup>

Table 2. Summary of changes in pediatric fracture injury mechanism & age patterns before and during coronavirus disease 2019 pandemic

Author	Country	Injury mechanism: number of patients	Age
Baxter et al. <sup>22)</sup>	United Kingdom	Sport: 82 (34.2%) → 5 (4.6%) Fall from standing: 42 (17.5%) → 24 (21.8%) Bike/scooter/rollerblades: 19 (7.9%) → 22 (20.0%)	11 Years of 240 cases → 8 years of 110 cases
Bolzinger et al. <sup>23)</sup>	France		9.3 Years of 91 cases → 7.6 years of 81 cases
Li et al. <sup>25)</sup>	China		Infants: 285 (14.40%) → 157 (18.21%) Preschool children: 657 (33.20%) → 344 (39.91%) School children: 819 (41.38%) → 312 (36.19%) Adolescents: 218 (11.02%) → 49 (5.68%)
Bram et al. <sup>27)</sup>	United States of America	Home: 468 (32.5%) → 177 (57.8%) Sports: 374 (26.0%) → 22 (7.2%) Public/street: 266 (18.5%) → 74 (24.2%) School/daycare: 154 (10.7%) → 1 (0.3%) Playground: 129 (9.0) → 16 (5.2%) Low-energy injury: 352 (24.5%) → 65 (21.2%) High-energy injury: 312 (21.7%) → 103 (33.7%) Body-powered vehicle: 118 (8.2%) → 56 (18.3%) Motor vehicle accident: 26 (1.8%) → 16 (5.2%) Direct blow: 243 (16.9%) → 42 (13.7%)	Aged under 5: 358 (24.9%) → 119 (38.9%) Aged 6 to 11: 617 (42.9%) → 137 (44.8%) Aged over 12: 464 (32.2) → 50 (16.3%)
Oguzkaya et al. <sup>28)</sup>	Turkey	Low-energy trauma: 220 → 51 High-energy trauma: 158 → 16 (e.g., fall from height, motor vehicle accident)	11.2±4.4 Years of of 378 cases → 9.4±3.6 years of of 67 cases
Ruzzini et al. <sup>30)</sup>	Italy	Domestic traumas: 294 (32.3%) → 143 (82.6%) Sports: 316 (34.7%) → 9 (5.2%)	
Darling et al. <sup>31)</sup>	United Kingdom		11.1 Years of 54 cases → 6.9 years of 13 cases

## Changes in ages at pediatric fracture after COVID-19 outbreak

According to a report in the United Kingdom,<sup>22)</sup> the average age of 240 pediatric fracture patients in 2019 before the pandemic was 11 years, whereas that of 110 patients during the pandemic was 8 years. In France,<sup>23)</sup> the average age of 91 patients who underwent surgery in 2019 was 9.3 years; in 2020, the average age of 81 patients was 7.6 years. According to another report in the United Kingdom,<sup>31)</sup> the average age of pediatric orthopedic patients was 11.1 years in the nonlockdown period versus 6.9 years in the lockdown period.

A study in China<sup>25)</sup> divided pediatric fracture patients into four age groups and noted a decrease in the number of fractures between the prepandemic and pandemic periods: infants (285 [14.40%]) to 157 [18.21%], preschool children (657 [33.20%]) to 344 [39.91%], school children (819 [41.38%]) to 312 [36.19%], and adolescents (218 [11.02%]) to 49 [5.68%]). Due to COVID-19 lockdown measures, children were prohibited from attending school, and the proportion of pediatric patients who were relatively older and attend school has decreased significantly.

Bram et al.<sup>27)</sup> classified the age groups of pediatric fracture patients in the United States from 2018 to 2019 and 2020, with reductions in cases from 358 (24.9%) to 119 (38.9%) for children aged <5 years, 617 (42.9%) to 137 (44.8%) for those aged 6–11 years, and from 464 (32.2) to 50 (16.3%) for those aged >12 years.

A study in Turkey<sup>28)</sup> reported an age change in 378 patients comparing the pandemic period to 2019, with an average age of  $11.2 \pm 4.4$  in 67 patients and  $9.4 \pm 3.6$  in 67 patients, respectively. The results are summarized in Fig. 3 and Table 2.

According to NHIS and NHSPIC data, the number of fractures during the prepandemic and pandemic periods decreased from 7,384 to 2,539, 9,318 to 5,360, and 10,011 to 5,854 in 11-, 12-,

and 13-year-olds, respectively. These data clearly show an overall decrease in the incidence of fractures in adolescents attending school.

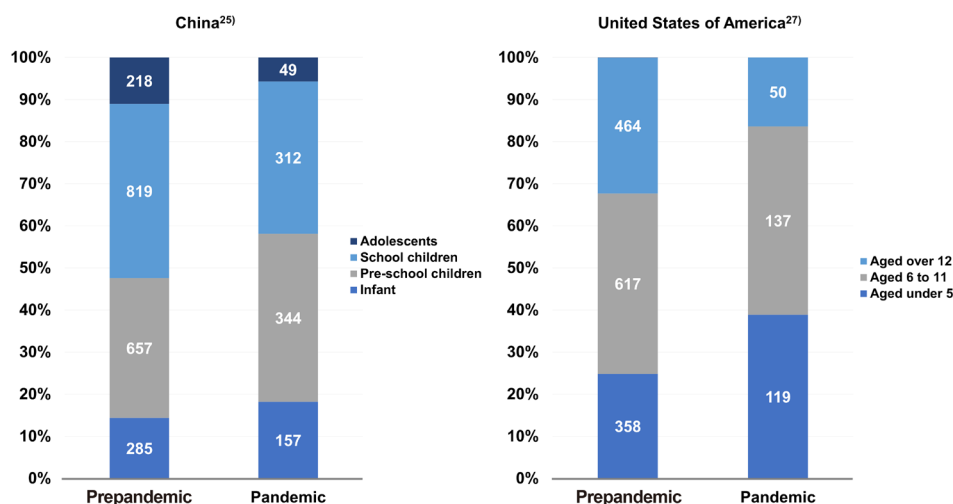
## Conclusion

Considering various aspects of pediatric fracture worldwide, it is clear that the number of trauma-related fractures has decreased, accompanied by an increased number of preschool-age fractures. Moreover, most pediatric fractures before the COVID-19 pandemic were sports-related. As both academic and social meetings were suspended due to lockdown policies, a decreased number of pediatric fractures, including sports-related fractures, was expected because of decreased physical and outdoor activities. Moreover, it seems reasonable that the proportion of fracture patients with relative skeletal immaturity would increase significantly. The proportion of COVID-19 vaccinated individuals is gradually increasing worldwide, and if normal academic and sports activities increase owing to the easing of lockdown policies, the number of trauma patients related to increased activity may increase rapidly; thus, clinics should prepare for this change.

## Footnotes

Conflicts of interest: No potential conflict of interest relevant to this article was reported.

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**Fig. 3.** This is the change in the ratio of the age of pediatric fracture patients compared to 2019 and 2020. The overall number of patients decreased. However, due to the prevention policy of the coronavirus disease 2019 pandemic, children are prohibited from attending school, and the proportion of pediatric patients who are relatively older and attend school has decreased significantly.<sup>25,27)</sup>

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