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Original Article

Adolescent tibial tubercle fractures in the time of the COVID 19: A single orthopedic trauma center experience



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ABSTRACT

Background: The purpose of this study is to assess the incidence and clinical characteristics of adolescent tibial tubercle fractures (TTFs) during the COVID-19 pandemic by sharing our experiences.

Methods: Pediatric patients aged between 0 and 18 years old with confirmed diagnosis of TTFs who were treated at our center between April 2020 and May 2020 were included in the study. In addition to demographics, mechanism injury, treatment modalities, complications were also noted.

Results: Sixteen patients were included in the study. The mean age was 14.8 ± 0.9 years (range: 13–16 years). The mean BMI of patients was 26.3 ± 2.3 kg/m² (range: 23.2–30.4 kg/m²). According to the BMI-for-age percentiles growth chart, eight patients (50%) were overweight, and eight patients (50%) were at a risk of being categorized as overweight. The most common cause for the injury was jumping due to basketball (50%). Twelve of 16 patients were treated operatively by open reduction and internal fixation. The remaining 4 patients were treated non-operatively with long leg cast.

Conclusion: The incidence of TTFs was 16 cases over about two months during the pandemic isolation period. Our results demonstrated that all adolescent TTFs occurred during periods when outdoor activities were permitted. This finding may be explained by sudden athletic activity after prolonged immobilization. We observed that all of our patients were male and either overweight or at risk of being overweight.

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1. Introduction

Pediatric trauma has some different points from adults and the incidence is increasing over the years [1]. The increase in incidence is partly explained by changes in children's activity patterns over time [2]. With an estimated incidence of 0.25–2.7 cases per year, acute avulsion of the tibial tubercle is an atypical injury that accounts for less than 1% of all epiphyseal injuries [3]. Avulsion fractures of the tibial tubercle mostly occur in young and athletic males during jumping activities. Studies have described two most probable mechanisms of injury: the first is a powerful contraction of quadriceps during the take-off point before the jump while the knee is in full extension and the second is a rapid passive knee flexion against the contracting quadriceps during the groundstroke [3].

Since mid-December 2019, a new type of coronavirus infection that the World Health Organization (WHO) named the disease caused by the new coronavirus as coronavirus disease-2019 (COVID-19) has rapidly spread across all parts of the world. After proper evaluation, the WHO on March 12, 2020 announced that COVID-19 had attained the pandemic status [4]. To minimize the risk of COVID-19 transmission in the future, many countries have implemented different measures.

From April 3rd through the end of the month of May, 2020 special lockdown (or “curfew”) restrictions were put into effect by Turkish authorities for children under the age of 18 and adults above the age of 65. When the spread of virus began to slow, the beginnings of a normalization period were observed in Turkey. During this period, the authorities divided children into 2 groups as; (1) children at 14 years or under 14 years old and (2) children over 14 years of age. Each children age group had a 4-h outdoor weekly permission between 11 AM and 3PM, on Wednesdays and Fridays respectively. The purpose of this study is to assess the incidence and clinical characteristics of adolescent TTFs during the pandemic isolation period by sharing our experiences.

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2. Material and methods

2.1. Study population

This retrospective case-series study was performed after obtaining local ethical committee approval and conducted in accordance with the *Declaration of Helsinki*. We retrospectively analyzed the data of patients aged between 0 and 18 years who were admitted to our trauma center between two time periods: April 2019–May 2019 (normal period) and April 2020–May 2020 (lockdown period). The lockdown period was 59 days. Pediatric patients aged between 0 and 18 years old with confirmed diagnosis of TTF who were treated at our tertiary hospital between April 2020 and May 2020 were included in the study. Our hospital is Level III trauma center located in the city center of Istanbul—one of the world's largest metropolitan cities, with a population of over 15 million persons. During the COVID-19 lockdown period, patients who suffered from trauma were mostly admitted to our center, and elective surgeries were abandoned despite emergent orthopedic surgeries such as oncologic surgeries and trauma surgeries. This nationwide situation decreased the ratio of elective surgeries and increased the frequency of trauma surgeries, thus there was no special increase related to our center.

2.2. Data evaluation

Patients' medical records as well as radiographs were reviewed through our hospital's computer database. Additionally, we recorded each patients' age, gender, definite diagnosis, anatomic location of the fracture, type of fracture (fracture, fracture dislocation, open fracture, etc.), type of pediatric fracture (displaced fracture, torus fracture, epiphyseal fracture, pathological fracture, etc.), and treatment method (non-operative/operative). The phone numbers of the parents of these patients were obtained via hospital records. The parents were contacted. The last measured height and weight values of the patients before the pandemic were obtained. According to this information, the BMI for their age percentiles were calculated.

The radiographic data of each patient was recorded and reviewed by a single experienced surgeon (F.Y.) and the author of this study (A.K.). Two observers discussed the radiographs and came to an agreement on classification where there was some dispute. Finally, two authors were on agreement for all the x-rays. Ogden classification was used to define the fracture types [5] (Fig. 1).

We also retrospectively analyzed the data of all patients with confirmed diagnosis of TTF who were treated at our trauma center between years 2013 and 2020. Patient medical records as well as radiographs were reviewed through our hospital's computer database. Additionally; demographic data (age, gender, height, weight), mechanism of injury, treatment methods and fracture types were assessed.

3. Results

3.1. Demographic data

There were 504 pediatric fractures treated during lockdown period at our trauma center. Table 1 shows a comparison of the patients' demographics, anatomic locations of the fractures and the characteristics of the pediatric fractures observed during the normal period (2019) and lockdown period (2020). 16 of these 504 fractures were TTFs, and had open tibia proximal physes. TTFs accounted for 3.2% percent of all pediatric fractures, 13.3% percent of all pediatric lower extremity fractures, 67% percent of

all pediatric epiphyseal fractures and 4.6% percent of all adolescent fractures.

A total of 16 patients (16 male) with the diagnosis of TTF were treated during lockdown period. One patient had accompanying tibia distal epiphysiolysis. Another had accompanying radius distal epiphysiolysis. The mean age at the time of hospital admission was 14.8 ± 0.9 years (range: 13–16 years). The mean BMI of patients was 26.3 ± 2.3 kg/m² (range: 23.2–30.4 kg/m²). According to the BMI-for-age percentiles growth chart, eight patients were overweight, and eight patients were at a risk of being overweight category. Prior to lockdown six patients were overweight, and ten patients were at a risk of being overweight category (Table 2).

3.2. Diagnosis and mechanism of injury

All fractures had occurred on those days when the patients went out during their official 4-h excursion time amid the normalization period. The most common symptoms at presentation were tenderness, sharp pain, and severe swelling. The mechanisms of the injury and classifications according to Ogden classification were demonstrated in (Table 3).

3.3. Treatment

The indications for surgical treatment are type 2–5 fractures and displacement more than 2 mm or displacement more than 2 mm after closed reduction and cast immobilization in our hospital. Open Reduction Internal Fixations (ORIF) are performed through a midline incision in the knee. Cancellous 4.0 screws are used for optimal compression during internal fixation. Soft tissue repair are performed for Type V (periosteal sleeve) fractures. In total, 12 patients were treated with open reduction and internal fixation by using screws (Fig. 2). All the patients were immobilized with a cast, and all were disallowed weight-bearing after surgery. Three patients who had type 1A fractures were conservatively treated by immobilizing the knee in a long-leg circular cast in extension for six weeks. One patient who had type 4 fracture could not be operated due to obesity related co-morbidities (Fig. 3). This patient was also conservatively treated with closed reduction and a long-leg circular cast.

3.4. Complications

One patient underwent debridement due to the prolonged drainage (fluid drainage from the wound) on the 7th postoperative day and successfully recovered without the need for an additional intervention. No other complications occurred at the early post-operative period, and no other complications were detected up to time of the last follow-up.

3.5. Tibia tubercle fractures before COVID-19 pandemic lockdown period

A total of 18 (18 male) TTFs who were treated at our center during the pre-pandemic period of 2013–2019 were identified. The mean age at the time of hospital admission was 14.4 ± 0.98 years (range: 13–16 years). The mean postoperative follow-up time was 39.8 ± 12.5 months (ranges, 22–86 months). The mean BMI of patients was 25.8 ± 2.5 kg/m² (range: 22.5–32.1 kg/m²). According to the BMI-for-age percentiles growth chart, seven patients were overweight, eight patients were at a risk of being overweight and three patients were healthy weight category (Table 4). The most common symptoms at presentation were tenderness, sharp pain, and severe swelling. The most common cause for the injury was jumping or kicking due to soccer (39%). When we compare TTFs in

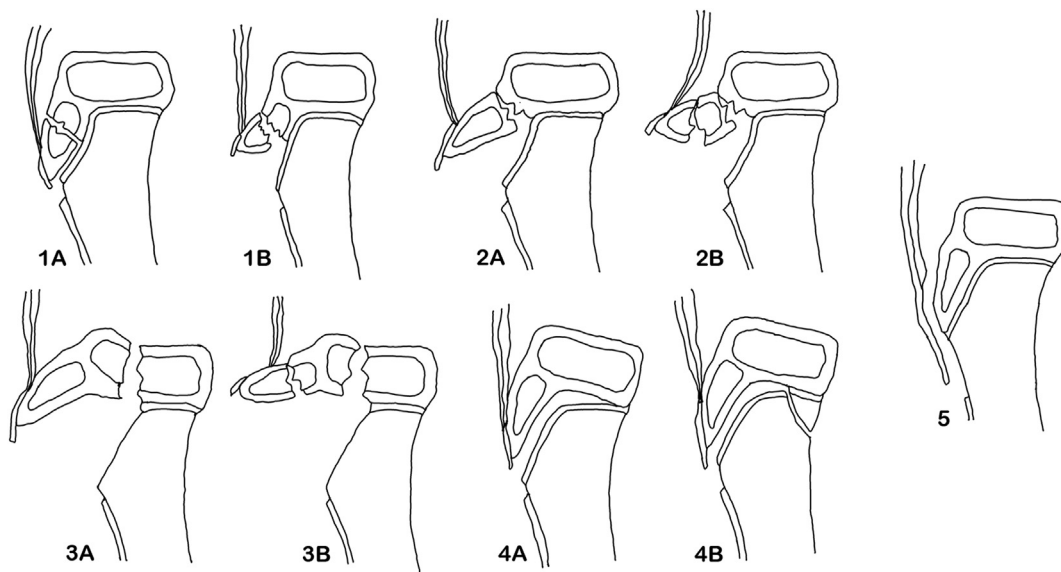


Fig. 1. Ogden Classification, **Type 1:** fracture of the secondary ossification center near the insertion of the patellar tendon, **Type 2:** fracture propagates proximal between primary and secondary ossification centers, **Type 3:** coronal fracture extending posteriorly to cross the primary ossification center, **Type 4:** fracture through the entire proximal tibial physis, **Type 5:** periosteal sleeve avulsion of the extensor mechanism from the secondary ossification center. **Modifier:** A (nondisplaced), B (displaced).

Table 1
Comparison of the patients' demographics, anatomic locations of the fractures and the characteristics of the pediatric fractures observed during the normal period (2019) and lockdown period (2020).

	2019 normal period (n = 596)	2020 lockdown period (n = 504)
Age, mean ± standard deviation	8.9 ± 4.9	7.3 ± 5.1
Gender		
Girl	216	168
Boy	380	336
Anatomic Location		
Clavicle	23	22
Humerus	13	6
Elbow	121	194
Forearm	81	44
Wrist	143	68
Hand	107	50
Hip	2	2
Femur	14	16
Patella	6	0
TTFs	1	16
Tibia	20	28
Ankle	33	17
Foot	32	41
Type of Trauma		
Closed Fracture	584	501
Open Fracture	2	0
Fracture - Dislocation	10	3
Type of Pediatric Fracture		
Displaced Fracture	435	423
Torus Fracture	127	57
Epiphyseal Fracture	33	24
Pathological Fracture	1	0
Type of Treatment		
Non-operative	555	430
Operative	41	74

TTFs: Tibial Tubercle Fractures, n: Number.

lockdown period in 2020 and normal period between 2013 and 2019 no significant difference was observed between two time periods in terms of mean age and BMI. The mechanisms of the injury and assortment according to Ogden classification were demonstrated in [Table 5](#).

Table 2
Demographics of the TTF patients during lockdown period.

Patient	Age	Height (cm)	Weight (kg)	BMI (kg/m2)	BMI-for-age percentile
1	14	176	85	27.4	97% (overweight)
2	14	176	94	30.3	100% (overweight)
3	16	184	83	24.5	86% (at risk of overweight)
4	16	184	86	25.4	90% (at risk of overweight)
5	15	173	91	30.4	99% (overweight)
6	15	186	85	24.6	90% (at risk of overweight)
7	13	170	67	23.2	91% (at risk of overweight)
8	16	180	87	26.9	94% (at risk of overweight)
9	14	175	74	24.2	91% (at risk of overweight)
10	14	163	64	24.1	96% (overweight)
11	16	185	84	24.5	86% (at risk overweight)
12	14	178	85	26.8	96% (overweight)
13	15	170	81	28	96% (overweight)
14	15	173	85	28.4	97% (overweight)
15	15	170	70	24.2	90% (at risk of overweight)
16	14	175	86	28	98% (overweight)

BMI: body mass index.

4. Discussion

The COVID-19 pandemic has affected all aspects of daily life. Curfews and lockdowns have been implemented all over the world to decrease the spread of the virus. These have resulted in the closing of schools, parks, and many other locations. With the implementation of these public health measures and the indefinite disbanding of organized sports, changes in injury patterns and treatment pathways are expected. Bram JT et al. found a reduction of nearly 60% in the average volume of pediatric fracture cases presenting to their institution during the COVID-19 pandemic as compared to the same period during 2018–2019 [6]. In the light of this information, although the incidence of tubercular fractures was expected to decrease, there was a significant increase in the number of tubercular fractures presented to our center. In this study, the incidence of TTFs was 16 cases over about two months during the pandemic isolation period. According to our clinical experience, this number is equal to the pediatric TTFs presented to the hospital between 2013 and 2019. COVID-19 isolation measures included the

Table 3
Mechanism, classification and treatment of the TTFs during lockdown period.

Patient	Fracture Side	Ogden Classification	Mechanism of injury	Treatment
1	Left	Type 3B	Basketball (jumping)	ORIF
2	Left	Type 4B	Basketball (jumping)	Long leg cast
3	Left	Type 3B	Basketball (jumping)	ORIF
4	Left	Type 3B	Basketball (jumping)	ORIF
5	Left	Type 3B	Basketball (jumping)	ORIF
6	Right	Type 3B	Basketball (jumping)	ORIF
7	Right	Type 3B	Trampoline (jumping)	ORIF
8	Left	Type 4B	Trampoline (jumping)	ORIF
9	Right	Type 1A	Soccer (kicking)	Long leg cast
10	Left	Type 1A	Soccer (kicking)	Long leg cast
11	Left	Type 4B	Fall from a height	ORIF
12	Left	Type 4B	Basketball (jumping)	ORIF
13	Right	Type 4B	Fall from a height	CRIF
14	Right	Type 2B	Basketball (jumping)	ORIF
15	Right	Type 4B	Fall from a height	ORIF
16	Left	Type 1A	Fall from a height	Long leg cast

ORIF: Open reduction internal fixation, CRIF: Closed reduction internal fixation.

closing of schools, parks and many other locations to decrease spread of the virus in Bram JT et al. study. In our study, isolation measures included implementing in the form of a curfew to those who are under the age of 18. Sports activities performed after a long

period of immobilization due to the lockdown in adolescents may have caused the fracture to increase.

According to the literature, the avulsion fracture of tibial tubercle occurs more frequently in males because of their more prevalent participation in the sports activities and the fact that physical closure occurs later in male than in female [7–9]. These fractures mainly affect adolescents. The mean age at which the fracture is frequently observed is at 14.6 years (range: 13–16 years) [10]. In our study, the mean age was also 14.8 years (range: 13–16 years) similar to the literature, and all the patients were male. According to our findings, all our patients' fractures had occurred at the days going out for 4 h during the normalization period after two months starting from the lockdown period. This fracture may be related to the use of extremities after a significant period of inaction and exposure to sudden and uncontrolled strong extensor power contraction during activities-thus causing this fracture. To date, we have been unable to find any studies evaluating those fractures which occurred after prolonged physical inactivity. However, in their study involving 3534 children, Karlsson et al. reported that an increase in daily school activity reduced the fracture risk [11]. Our current knowledge supports the importance of activity in bone remodeling. This is a lifelong process and increased avulsion fracture after prolonged inactivity may also be introduced for this reason.

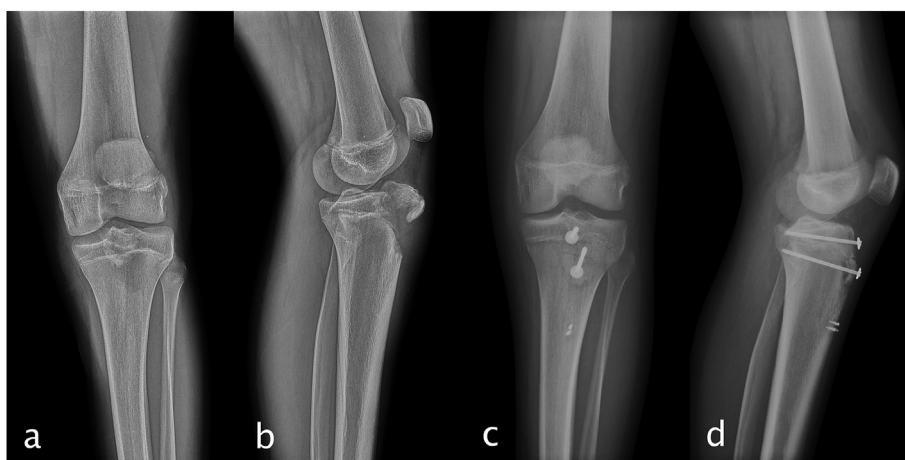


Fig. 2. Anteroposterior (a) and lateral (b) radiographs of a 16 years-old male with Type 3B TTF which occurred while playing basketball. Postoperative anteroposterior (c) and lateral radiographs (d) showing that open reduction and internal fixation was performed.



Fig. 3. Anteroposterior (a) and lateral (b) radiographs of a 14 years-old male with type 4B TTF. Anteroposterior (c) and lateral radiographs (d) showing that the patient was treated by closed reduction and long leg cast.

Table 4
Demographics of the patients with TTF (between 2013 and 2019).

Patient	Age	Height (cm)	Weight (kg)	BMI (kg/m ²)	BMI-for-age percentile
1	16	175	90	29.4	97% (overweight)
2	13	174	85	28.1	98% (overweight)
3	14	180	85	26.2	96% (overweight)
4	13	171	94	32.1	103% (overweight)
5	14	178	87	27.5	97% (overweight)
6	16	180	80	24.7	87% (at risk of overweight)
7	15	176	75	26.8	88% (at risk of overweight)
8	14	174	81	23.5	96% (overweight)
9	14	177	79	25.2	93% (at risk of overweight)
10	14	175	72	23.5	89% (at risk of overweight)
11	14	175	77	25.1	93% (at risk overweight)
12	14	179	81	27.8	97% (overweight)
13	15	178	77	24.3	89% (at risk of overweight)
14	14	174	68	22.5	86% (healthy weight)
15	15	179	85	26.5	94% (at risk of overweight)
16	13	176	78	25.2	95% (at risk of overweight)
17	16	182	79	23.8	82% (healthy weight)
18	15	178	72	22.7	80% (healthy weight)

BMI: body mass index.

Table 5
Mechanism, classification and treatment of the TTF treated between 2013 and 2019.

Patient	Fracture Side	Ogden Classification	Mechanism of injury	Treatment
1	Left	Type 3B	Soccer (jumping)	ORIF
2	Left	Type 1A	Fall from a height	CRIF
3	Right	Type 3B	Soccer (kicking)	ORIF
4	Left	Type 3B	Soccer (kicking)	ORIF
5	Left	Type 1B	Soccer (kicking)	ORIF
6	Left	Type 3B	Soccer (jumping)	ORIF
7	Right	Type 1B	Soccer (kicking)	ORIF
8	Left	Type 3B	Trampoline (jumping)	ORIF
9	Left	Type 3B	Soccer (kicking)	ORIF
10	Left	Type 3B	Basketball (jumping)	ORIF
11	Left	Type 3B	Street game (jumping)	ORIF
12	Right	Type 1B	Running away from the dog (sprinting)	ORIF
13	Left	Type 4B	Basketball (jumping)	ORIF
14	Left	Type 1A	Trampoline	CRIF
15	Right	Type 1B	Street game (direct trauma)	ORIF
16	Left	Type 3B	Skiing (jumping)	ORIF
17	Right	Type 2B	Basketball (jumping)	ORIF
18	Left	Type 3B	Fall from a height	ORIF

ORIF: Open reduction internal fixation, CRIF: Closed reduction internal fixation.

Gilbert et al. reported that obese patients were more likely to sustain the fractures involving the physical activities, and other studies have also reported that obesity is associated with fractures in children [12–16]. Shin YW et al. suggested that extreme BMI may be a risk factor for tibial tubercle avulsion fractures in adolescents during running without a definite trauma according to the results obtained from their study of evaluating 30 patients with TTF [17]. Recent studies have noted the decrease in physical activity and increase in sedantary behaviour in a pandemic [18,19]. Obesity and sedantary behaviour are potential risks regarding the development of further diseases. Kim et al. reported that obese children are more likely to have extremity fractures than their non-obese counterparts [20].

TTF often occurs during sports after the abrupt contraction of the quadriceps muscle [21]. Basketball, high jumping, football, and

sprinting are the sports that are most frequently associated with the TTFs [9]. In this study, many of our patients injured their knees while jumping, and the most common sport activity was basketball. This is one of the most popular sport activities among adolescents, and it should be noted that soccer fields were also closed during the lockdown period. Hence, more children would favor playing basketball and utilize the available playground facilities. It follows that after a long period of immobilization due to a lockdown or similar conditions, adolescents ought to engage cautiously in limited athletic activities.

This study has some potential limitations. The main limitation of this study is narrow study cohort. However, TTF is a very rare condition with a limited number of reported studies in the literature. Studies with a larger cohort are required to determine whether intense action during sports activity after prolonged immobilization is a risk factor for tibial tubercle avulsion fracture. Second limitation is that bone mineral density could be checked to see if these patients were prone to fracture, unfortunately, this data was not available. Another limitation is that no inter-observer or intra-observer correlation analysis was performed between observers. The main strength of this study is it being the first in the literature to evaluate the intriguing increase in adolescent TTFs during the COVID-19 pandemic from a single-center perspective. Nevertheless, this is a single-center study focusing on a period of 2 months only. As such, any observed increase in incidence may be incidental.

5. Conclusion

The incidence of TTFs was 16 cases over about two months during the pandemic isolation period. Our results demonstrated that all adolescent TTFs occurred during times when outdoor activities were permitted. This finding may be explained by sudden and intense athletic activity after prolonged immobilization. We observed that all our patients were male and either overweight or at risk of being overweight. The most common etiology was injuries resulting from jumping, which occurred while playing basketball. Twelve of sixteen patients (75%) needed surgical intervention for the treatment of displaced fractures.

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Declaration of competing interest

There are no conflicts of interest.

References

- [1] Civan O, Alimoğlu B, İcen M, Taşkın S, Cavit A, Söyüncü Y, Urguden M. Pediatric tibial shaft and distal metaphyseal fractures. *Jt Dis Relat Surg* 2020;31(3): 532–40.
- [2] Hedström EM, Svensson O, Bergström U, Michno P. Epidemiology of fractures in children and adolescents. *Acta Orthop* 2010 Feb;81(1):148–53.
- [3] Hamilton SW, Gibson PH. Simultaneous bilateral avulsion fractures of the tibial tuberosity in adolescence: a case report and review of over 50 years of literature. *Knee* 2006 Oct;13(5):404–7.
- [4] She Jiatong, Liu Langin, Liu Wenjun. COVID-19 epidemic: Disease characteristics in children. *J Med Virol* 2020;92(7):747–54. <https://doi.org/10.1002/jmv.25807>. ISSN 1672-3619, CN 44-1503/R.
- [5] Ogden JA, Tross RB, Murphy MJ. Fractures of the tibial tuberosity in adolescents. *J Bone Joint Surg Am* 1980 Mar;62(2):205–15.
- [6] Bram JT, Johnson MA, Magee LC, Mehta NN, Fazal FZ, Baldwin KD, Riley J, Shah AS. Where have all the fractures gone? The epidemiology of pediatric fractures during the COVID-19 pandemic. *J Pediatr Orthop* 2020 Sep;40(8): 373–9.
- [7] Chow SP, Lam JJ, Leong JC. Fracture of the tibial tubercle in the adolescent. *J Bone Joint Surg Br* 1990 Mar;72(2):231–4.

- [8] McKoy BE, Stanitski CL. Acute tibial tubercle avulsion fractures. *Orthop Clin N Am* 2003 Jul;34(3):397–403.
- [9] Jakoi A, Freidl M, Old A, Javandel M, Tom J, Realyvasquez J. Tibial tubercle avulsion fractures in adolescent basketball players. *Orthopedics* 2012 Aug;1;35(8):692–6.
- [10] Pretell-Mazzini J, Kelly DM, Sawyer JR, Esteban EMA, Spence DD, Warner WC, Beaty JH. Outcomes and complications of tibial tubercle fractures in pediatric patients: a systematic review of the literature. *J Pediatr Orthop Jul-Aug 2016;36(5):440–6.*
- [11] Karlsson M, Lahti A, Cronholm F, Dencker M, Karlsson C, Rosengren B. Daglig skolidrott ger ökad benmassa och successivt minskad frakturrisik - resultat från Bunkefloprojektet [Daily school physical activity increases bone mass and gradually reduce the fracture risk]. *Lakartidningen* 2019 Mar 19;116. FHP7. Swedish.
- [12] Dimitri P, Bishop N, Walsh JS, Eastell R. Obesity is a risk factor for fracture in children but is protective against fracture in adults: a paradox. *Bone* 2012 Feb;50(2):457–66.
- [13] Kessler J, Koebnick C, Smith N, Adams A. Childhood obesity is associated with increased risk of most lower extremity fractures. *Clin Orthop Relat Res* 2013 Apr;471(4):1199–207.
- [14] Leonard MB, Shults J, Wilson BA, Tereshakovec AM, Zemel BS. Obesity during childhood and adolescence augments bone mass and bone dimensions. *Am J Clin Nutr* 2004 Aug;80(2):514–23.
- [15] Sabhaney V, Boutis K, Yang G, Barra L, Tripathi R, Tran TT, Doan Q. Bone fractures in children: is there an association with obesity. *J Pediatr* 2014 Aug;165(2):313–8.
- [16] Gilbert SR, MacLennan PA, Backstrom I, Creek A, Sawyer J. Altered lower extremity fracture characteristics in obese pediatric trauma patients. *J Orthop Trauma* 2015 Jan;29(1):e12–7.
- [17] Shin YW, Kim DW, Park KB. Tibial tubercle avulsion fracture according to different mechanisms of injury in adolescents: tibial tubercle avulsion fracture. *Medicine (Baltim)* 2019 Aug;98(32).
- [18] Bates LC, Zieff G, Stanford K, Moore JB, Kerr ZY, Hanson ED, Barone Gibbs B, Kline CE, Stoner L. COVID-19 impact on behaviors across the 24-hour day in children and adolescents: physical activity, sedentary behavior, and sleep. *Children* 2020 Sep16;7(9):138.
- [19] López-Bueno R, López-Sánchez GF, Casajús JA, Calatayud J, Gil-Salmerón A, Grabovac I, Tully MA, Smith L. Health-related behaviors among school-aged children and adolescents during the Spanish covid-19 confinement. *Front Pediatr* 2020 Sep 11;8:573.
- [20] Kim SJ, Ahn J, Kim HK, Kim JH. Obese children experience more extremity fractures than nonobese children and are significantly more likely to die from traumatic injuries. *Acta Paediatr* 2016 Oct;105(10):1152–7.
- [21] Polakoff D, Bucholz R, Ogden J. Tension band wiring of displaced tibial tuberosity fractures in adolescents. *Clin Orthop Relat Res* 1986 Aug;(209):161–5.