



## Children with supracondylar humerus fractures have an increased risk of attention deficit hyperactivity disorder

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Children with attention deficit hyperactivity disorder (ADHD) have an increased risk of sustaining fractures during their preschool years. Supracondylar humerus fractures (SHFs) comprise the majority of fracture surgeries in the pediatric age range. We hypothesized that ADHD symptoms would be present in children with SHFs, and this characteristic trauma may be associated with an ADHD diagnosis. Thus, we compared the ADHD symptoms of children with and without SHFs. Further, we compared the trauma characteristics, gender, proneness to injury, and presence of prior trauma history of children diagnosed with and without ADHD. We recruited 41 children who were admitted to emergency service with an SHF and 41 age- and gender-matched children without a fracture history. A semi-structured diagnostic interview and a Swanson Nolan Pelham questionnaire were used to obtain data about ADHD symptoms. A clinical intake form was utilized for further clinical data. ADHD symptoms were significantly higher in the fracture group; male gender, parent-reported proneness to injury, and prior history of trauma were significantly associated with ADHD. Orthopedic surgeons may provide early detection of ADHD by using screening tools or asking questions to caregivers and making referrals when needed. This may lead to prevention of further injuries.

**Keywords :** Supracondylar humerus fractures ; children ; Attention Deficit Hyperactivity Disorder (ADHD) ; injury ; behavior.

### INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is a neurodevelopmental disorder characterized by persistent inattention, impulsivity, and hyperactivity. It is the most common psychiatric condition in school-aged children with a worldwide prevalence of 5.3 percent (1). Although ADHD is diagnosed most often in school-aged children, the symptoms emerge during early childhood and can interfere with functioning and development (2).

Children with ADHD are at greater risk for injuries (3). Among all childhood psychiatric disorders, ADHD is the one most associated with fractures. It has been found that the relationship between ADHD and fractures is independent of other comorbid psychiatric disorders (4). Also, it has been shown that the increase of fracture inci-

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dences is higher in females with ADHD than males with ADHD (4-6). It has been speculated that reckless behavior, clumsiness, the inability to abide by the rules of games or sports, and the failure to take prevention into consideration in children with ADHD, combined with a high probability of developmental coordination disorder, increase the risk of injury and fractures (7-8). Although studies have been conducted on the relationship between ADHD and fractures in children – mostly studies of cohorts using national databases to obtain ADHD rates in various fracture sites – the results are inconsistent (4,6,9,10).

Supracondylar humerus fractures (SHFs) are the most common elbow fractures in children under seven years old, and the majority of fracture surgeries in the pediatric age range are due to SHFs (11,12). While SHFs are seen in all pediatric ages, their incidence peaks in children between five and seven years old. This age range is similar to the age range when the primary symptoms of ADHD emerge (13). Gender distribution is found to be even, and the most frequent injury mechanism is falling on an extended arm, mostly on the non-dominant side (13-15). It has been previously documented that incidence of SHFs increases during school holidays, and SHFs often result from falls from playground equipment that require balance and motor coordination such as trampolines and monkey bars (14). One-third of SHFs are non-displaced fractures, which are treated with a long arm cast. Closed reduction percutaneous pinning is applied for displaced fractures (16).

The aim of this study is to investigate the symptoms of ADHD in children who presented to emergency services with SHF and to determine whether ADHD is a risk factor for sustaining SHFs. We hypothesize that the symptoms of ADHD are more frequent in children with SHF than in children without a fracture history. Our second hypothesis is that trauma characteristics such as the mechanism, place and time of the trauma, gender, proneness to injury, and presence of prior trauma history may differ among children with SHF according to the presence of ADHD.

## MATERIALS AND METHODS

A convenience sampling method was used. The subjects of the study were recruited from the orthopedics and traumatology clinic of our university hospital between January and July 2017. A total of 82 children between the ages of 3 and 17 participated. The study group (n=41, 14 females and 27 males with a mean age of  $7.9 \pm 2.7$  years) consisted of children consecutively admitted with SHFs. The diagnosis of SHF was made following a physical examination and conventional lateral and AP-view radiograph images. The control group (n=41, 14 females and 27 males with a mean age of  $8.0 \pm 2.8$ ) consisted of age- and gender-matched children who visited orthopedics consecutively for reasons other than trauma and had no prior trauma history. Children with fractures due to auto-pedestrian injuries, vehicle accidents, child abuse, pathological fractures, and polytrauma were excluded from the study. Further exclusion criteria for both study and control groups included having chronic or progressive musculoskeletal disease, known motor or intellectual disability, neurological diseases such as epilepsy, and any severe medical condition requiring continuous medical treatment or care. According to the exclusion criteria 4 children, who sustained SHF due to motor vehicle accidents were not included in the study.

The local ethics committee of our medical faculty approved the study, which was conducted in accordance with the ethical standards set out in the 1964 Declaration of Helsinki and was carried out in accordance with the relevant regulations of the U.S. Health Insurance Portability and Accountability Act (HIPAA). Informed consent was obtained from all individual participants included in the study. Written consent was obtained from one parent of each patient, and children's verbal consent was taken. The authors completed a clinical intake form, which was developed for the study. All of the subjects were interviewed using the Kiddie-Schedule for Affective Disorders and Schizophrenia-Present and Lifetime Version (KSADS-PL) to evaluate ADHD. The Swanson Nolan and Pelham questionnaire (SNAP) was used to evaluate ADHD symptoms.

The clinical intake form included questions regarding details about the trauma (mechanism, place, and time of the trauma), age and gender of the child, the child's medical and psychiatric history, prior trauma history, the child's parent-reported proneness to injury, the parent-reported perceived socioeconomic status (SES) of the family, and parental ages.

KSADS-PL, a semi-structured diagnostic interview based on the Diagnostic and Statistical Manual of Mental Disorders (4th ed. ; DSM-IV ; APA, 1994) criteria was used to make an ADHD diagnosis. This is a standardized interview used to collect signs and symptoms that can be used to make reliable DSM-IV diagnoses. To make an ADHD diagnosis, in addition to a sufficient number of behavioral symptoms, these symptoms should be present at two or more settings including home, school, friends, or relatives, and they should interfere with the daily functioning or the development of the child. This interview, which receives updating according to DSM criteria has been widely used as a valid diagnostic in child mental health research<sup>17</sup>. The reliability and validity of the Turkish version has been established. The author, who is certified to conduct KSADS-PL, carried out the interview for the present study. The diagnosis of ADHD was determined according to the child and parent interview.

SNAP is an 18-item scale derived from the DSM-IV criteria for ADHD. It consists of nine items for inattention (e.g., "Often has difficulty sustaining attention in tasks or play activities", "Often avoids, dislikes, or reluctantly engages in tasks requiring sustained mental effort", and "Often is forgetful in daily activities") and nine items for hyperactivity/impulsivity (e.g., "Often is 'on the go' or often acts as if 'driven by a motor,'" "Often interrupts or intrudes

on others (e.g., butts into conversations/games)", and "Often runs about or climbs excessively in situations in which it is inappropriate"). Each item is rated from 0 to 3 according to symptom frequency. In this study, parents completed the scale. It has profound psychometric features with coefficient alpha values of 0.94 for parent ratings. A Turkish validation of the scale has been conducted.

Data analyses were conducted using the Statistical Package for the Social Sciences (SPSS) v. 21. The descriptive data (frequencies and percentages for categorical variables and mean and standard deviation for continuous variables) were evaluated. Group comparisons were performed by Chi-square tests for categorical variables and by independent sample t-tests or Mann-Whitney U tests for continuous variables according to the normality tests. Analyses of variance were used for continuous variables. A probability level of  $p \leq .05$  was used to indicate statistical significance.

## RESULTS

The mean age, perceived SES, and parental ages of the two groups were comparable (Table I). The ADHD rate and the SNAP scores (both attention deficiency, hyperactivity/impulsivity, and total scores) were higher in the study group (Table II). ADHD rates in the study group were compared according to trauma mechanism, place of trauma, and time of the trauma ; there was no difference according to these variables (Table III). The majority of the fractures occurred due to ground-level falls, followed by falling from >1 meter, sports activities, bicycle injuries, and fighting. The ADHD rate was higher in children whose fractures occurred due to falling from >1 meter (n=8, 80%) ; however,

Table I. — Comparison of the groups according to sociodemographic variables

	Study Group (n=41)	Control Group (n=41)	p
Age, mean $\pm$ SD	7.9 $\pm$ 2.7	8.0 $\pm$ 2.8	0.918
Male gender, n(%)	27 (65.9%)	27 (65.9%)	1
Mothers' age, mean $\pm$ SD	35.3 $\pm$ 5.3	37.0 $\pm$ 4.3	0.115
Fathers' age, mean $\pm$ SD	39.7 $\pm$ 5.2	40.6 $\pm$ 4.6	0.396
Perceived socioeconomic status, n (%)			
Low	10 (24.4%)	7 (17.1%)	0.100
Medium	28 (68.3%)	24 (58.5%)	
High	3 (7.3%)	10 (24.4%)	

Table II. — Comparison of the two groups according to ADHD measures

	Study Group (n=41)	Control Group (n=41)	p
ADHD rate, n (%)	20 (48.8)	4 (9.8)	<.000**
SNAP scores, mean ± SD			
Attention Deficiency	7.6 ± 6.5	4.9 ± 3.2	0.022*
Hyperactivity/Impulsivity	10.3 ± 7.5	6.6 ± 4.3	0.007*
Total	17.8 ± 12.8	11.4 ± 6.0	0.005*

\*p&lt;0.05, \*\*p&lt;0.001

Table III. — Details of the trauma and ADHD rates according to the trauma settings

	N	%	ADHD diagnosis, N %	p
Trauma mechanism				
Falling	21	51.2	8 38.1	0.067
Falling >1mt	10	21.4	8 80.0	
Fighting	2	4.9	0 0	
Sports activities	4	9.8	3 75	
Bicycle injuries	4	9.8	1 25	
Place of the trauma				
Playground	24	58.5	12 50	0.898
School	7	17.1	3 42.9	
Home	7	17.1	3 42.9	
Sports area	3	7.3	2 66.7	
Time of the trauma				
08:00-12:00	9	22	5 55.6	0.698
12:00-16:00	17	41.5	9 52.9	
16:00-20:00	14	34.1	6 42.9	
20:00-24:00	1	2.4	0 0	

Table IV. — Comparison of the groups according to medical history

	ADHD Diagnosis		p
	N	%	
Gender			
Female	2	14.3	.003*
Male	18	66.7	
Prior Trauma History			
Present	12	70.6	0.028*
Absent	8	33.3	
Parent reported proneness to injury			
Present	15	88.2	<.000**
Absent	5	20.8	

\*p&lt;0.05, \*\*p&lt;0.001

this finding was not statistically significant. When the ADHD group (n=20) was analyzed, the most common mechanism of the trauma was falling, either at ground level or falling from >1 meter (n=16, 80%). The majority of the traumas occurred

during playground activities (n=24, 58.5%). The ADHD rate was comparable among the places of the trauma. There was no significant difference in ADHD rates according to the trauma characteristics (Table III).

When the study group was analyzed according to gender, the presence of prior trauma history, and parent-reported proneness to injury, the ADHD rate was significantly higher if male gender, prior history of trauma, or parent-reported proneness to injury was present (Table IV).

## DISCUSSION

The present study aimed to describe ADHD symptoms and the injury profile in SHFs. It was hypothesized that ADHD symptoms would be higher in children treated for SHFs than in children without a fracture history. This paper aimed to investigate this relationship as the age range of SHFs overlaps with the age when ADHD symptoms emerge, and early identification of ADHD may prevent further injuries.

In this study, we detected that the prevalence of ADHD symptoms in children with SHFs is higher than in children without a history of fracture. The prevalence of ADHD symptoms in children with SHFs was 48.8%. While this rate is considerably higher than the estimated population rate of ADHD, which is 5-8%, it is in accordance with the findings of previous studies investigating behavioral problems in children with fractures (9,18-20). Furthermore, prior trauma history, parent-reported proneness to injury, and male gender was significantly higher for the children who were diagnosed with ADHD. These findings may be explained by the fact that children with ADHD have been shown to be involved in unintentional injuries more frequently than their healthy peers (21). ADHD has a female

to male ratio ranging from 1:2.5 to 1:4, and the symptoms of hyperactivity and impulsivity, which are associated with injuries and fractures, tend to be more severe in boys than in girls (1,18).

SES, parental age, and children's age may affect the rate of ADHD. The age- and sex- matched control group were selected to prevent this effect ; perceived SES and parental ages were also similar in both groups. ADHD risk has been found to be associated with decreased parental age (22,23). In the current study, we used perceived SES as the SES measure, as subjective SES is found to be the best predictor of children's health in the family (24). There is an association between low socioeconomic status and increased risk of ADHD (25). ADHD symptoms generally emerge during preschool and the first year of school ; the mean age of the study group was  $7.92 \pm 2.70$ , which confirms the overlap of the age range between ADHD and SHFs. Both attention deficiency and hyperactivity/impulsivity scores were significantly higher in the study group, although the difference was greater in the hyperactivity/impulsivity subscale. This finding is consistent with earlier studies showing a greater association between fractures and hyperactivity/impulsivity behaviors rather than attention deficiency symptoms (9,18,26). We found higher rates of ADHD symptoms in children with SHFs than in children without a fracture history ; our results were also higher than the population rate (19). Our study is the first to investigate the association between ADHD and SHF ; however, other studies have investigated ADHD rates in various injuries and fractures. A comparison of the findings of these studies confirms that ADHD symptoms are frequent in injuries (4,10,18,20). In reviewing the literature, very little was found relating to the effectiveness of obtaining early diagnosis and treatment of ADHD and preventing further traumas. The most common age ranges of the children whose injuries have been investigated in previous studies are different from the age range for emergent ADHD symptoms. The mean age of SHF is similar to the age range when ADHD symptoms emerge. Early identification of ADHD may lead to early interventions, which are mostly non-pharmacological options such as parent training or classroom behavioral interventions

designed according to developmental periods (27). In our age- and sex-matched control group, the ADHD rate was similar with the population rate in Turkey (19). We consider that this data supports the reliability of our findings.

In accordance with the literature, the most common mechanism of injury that leads to SHFs was falls. Previous studies reported differences regarding injury mechanisms in children with ADHD. Uslu et al. reported that bicycle injuries, falling, and pedestrian injuries were more common (9). DiScala also reported that bicycle injuries were higher (28). In our study, the injury mechanisms and trauma characteristics did not differ between children with and without ADHD.

We found that children with ADHD had significantly higher previous musculoskeletal trauma history than children without ADHD. This is a consistent finding for fractures, unintentional injuries, and trauma-related emergency department visits. ADHD symptoms are known to decrease considerably after the initiation of treatment ; in addition, epidemiological studies show that children who are receiving treatment for ADHD have similar fracture rates as their non-ADHD peers and that treatment decreases the risk of injuries including bone fractures (4,29-31). We conclude that early identification and treatment of ADHD may reduce further fractures and also refractures. In addition to prior trauma history, male gender and parent-reported proneness to injury were significantly associated with an ADHD diagnosis. Gender difference is inevitable as neurodevelopmental disorders, including ADHD, are predominantly present in males. Perera et al. also found that children with ADHD were perceived by their parents to be prone to injury (32).

The first-line treatment for ADHD includes cognitive behavioral therapy and pharmacotherapy consisting of psychostimulants (4). School-aged children with moderate impairment may benefit from solely non-pharmacological interventions (27). Zheng et al. reported that the treatment of ADHD decreases the injury and fracture rate (26). In addition to increased injury risk, the delayed diagnosis and treatment of ADHD is associated with academic failure, social difficulties, low self-

esteem, delinquency, a lower quality of life, and a higher burden of disease. It was shown that people with ADHD had poorer long-term outcomes without treatment in all outcome measures of academic, antisocial behavior, driving, non-medicinal drug use/addictive behavior, obesity, occupation, services use, self-esteem, and social functioning compared with people without ADHD, and these outcomes were improved in people with ADHD who received treatment (33). Due to the high rate of ADHD in children with SHF, we suggest using ADHD symptom checklists like SNAP and asking parents about hyperactive/impulsive behaviors, previous injuries of their children, and whether their child is prone to injuries. Seeking a neurodevelopmental and behavioral evaluation when ADHD is suspected may provide early diagnosis and treatment of ADHD and prevent further injuries and probable comorbidities as well as reduce the total treatment cost.

Our findings should be considered within the limitations of our study. The sample size of the study is small. This limitation may be due to our decision to use a cross-sectional design rather than utilizing retrospective data. A child psychiatrist examined all of the subjects within two weeks after the fracture. Many of the previous studies were large cohort studies where information about the family's SES and whether the trauma was unintentional, pathological, or abuse-related was not available. Furthermore, the age- and sex-matched control group design enhances the quality of our data. A subgroup analyses of adolescents would be informative, although our sample size was not sufficient. Another limitation of our study is that the fracture type, length of stay at the hospital, and treatment outcomes of the children with and without ADHD were not compared. Some studies have shown that length of stay is longer and treatment outcome is poorer in children with ADHD. However, the prognosis of the SHFs are beyond the scope of this study. It is evident that studies with larger sample sizes are needed to conduct this comparative analysis. Children with a diagnosed developmental disorder or intellectual disability were excluded from the study ; however, we did not conduct a test to evaluate intelligence quotient. We believe that the

child psychiatrist would be aware of an intellectual disability during the KSADS-PL interview. The KSADS-PL according to the DSM-IV was used, as the updated KSADS-PL for the DSM-5 had not been translated and validated for Turkish population at the time of the study. In DSM-5 the minimum age of onset for the symptoms has been changed from 7 years to 12 years. The author was trained to conduct KSADS-PL ; however, the presence of a second clinician conducting KSADS-PL would make it possible to measure inter-rater validity. The dominant side and motor skills were not evaluated, although our aim was not to identify the underlying mechanisms of increased SHFs in ADHD but rather the prevalence and predictors.

## CONCLUSION

The prevalence of ADHD symptoms in children who have sustained a SHF is high. The diagnosis and treatment of ADHD depends on the awareness about ADHD of parents, teachers, and healthcare providers caring for the child. Based on our findings, we suggest that recognition of ADHD by orthopedic surgeons and emergency physicians is essential. Utilizing screening tools or asking simple definitive questions to caregivers about the child's behavior, prior injuries, and proneness to injury and conducting appropriate referrals may result in early detection and treatment of ADHD and lead to the prevention of further injuries. Children with a prior fracture history, reported as prone to injury by parents, and boys are more likely to have ADHD ; thus, these children may be in the most need of screening.

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