



Evaluation of Fall Frequency in Children with Cerebral Palsy: A Controlled Study

Serebral Palsili Çocuklarda Düşme Sıklığının Değerlendirilmesi: Kontrollü Çalışma

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Abstract

Objective: This study aimed to compare fall frequency, fall characteristics, and fall-related injuries between children with cerebral palsy (CP) and healthy controls.

Method: This cross-sectional, controlled study included 23 children with CP and 23 healthy children, all aged 5-12 years. Demographic characteristics, fall frequency, injury type, fall location, and activity during the fall were recorded based on caregiver reports. Children with CP were further assessed using the gross motor function classification system (GMFCS) and the functional ambulation classification scale. Participants were grouped by fall frequency into lower- and higher-frequency groups. This trial was registered at ClinicalTrials.gov (Identifier: NCT06679166).

Results: At least one fall within the last six months was reported by 91.3% of children with CP and by 65.2% of healthy children. A higher fall frequency was observed in 43.5% of children with CP, whereas none of the healthy controls were classified in the higher-fall-frequency group. In the CP group, most falls occurred at home during walking, whereas in the control group, most falls occurred outdoors during running. The most common injuries in the CP group were sprains, contusions, and pain. No fractures or serious injuries were reported in either group. In the CP group, children with higher fall frequency were most commonly classified as GMFCS level II; however, this association was not statistically significant.

Conclusion: Children with CP fall more frequently than their healthy peers, particularly while walking. Even minor injuries may reduce activity, confidence, and well-being, highlighting the need for fall-focused rehabilitation strategies.

Keywords: Cerebral palsy, child, fall

Öz

Amaç: Bu çalışma, serebral palsili (SP) çocuklar ile sağlıklı kontroller arasında düşme sıklığını, özelliklerini ve düşmeye bağlı yaralanmaları karşılaştırmayı amaçlamaktadır.

Yöntem: Bu kesitsel kontrollü çalışmaya 5-12 yaşları arasında 23 SP'li çocuk ve 23 sağlıklı çocuk dahil edildi. Demografik özellikler, düşme sıklığı, yaralanma türü, düşme yeri ve düşme anındaki aktivite bakımverenlerden alınan bilgilere göre kaydedildi. SP'li çocuklar ayrıca kaba motor fonksiyon sınıflandırma sistemi (GMFCS) ve fonksiyonel ambulasyon sınıflaması ile değerlendirildi. Katılımcılar düşme sıklığına göre düşük ve yüksek düşme sıklığı grupları olarak sınıflandırıldı (Bu çalışma ClinicalTrials.gov adresinde kayıt altına alınmıştır (Tanımlayıcı: NCT06679166)).

Bulgular: SP'li çocukların %91,3'ü ve sağlıklı çocukların %65,2'sinde son altı ay içinde en az bir düşme bildirildi. SP'li çocukların %43,5'inde sık düşmeler gözlenirken, sağlıklı kontrollerin hiçbir düşme sıklığı daha yüksek olanlar grubunda sınıflandırılmadı. SP grubunda düşmelerin çoğu yürüme sırasında ve ev ortamında meydana gelirken, kontrol grubunda daha çok koşma sırasında ve ev dışında görüldü. SP grubunda yaralanmalar en sık burkulma, ardından kontüzyon ve ağrı şeklindeydi. Her iki grupta da kırık veya ciddi yaralanma bildirilmedi. SP grubunda daha yüksek düşme sıklığına sahip çocuklar en yaygın olarak GMFCS seviye II olarak sınıflandırıldı, ancak bu ilişki istatistiksel olarak anlamlı değildi.

Sonuç: SP'li çocuklar, özellikle yürüme sırasında, sağlıklı akranlarına göre daha sık düşmektedir. Küçük yaralanmalar dahi aktiviteyi, güveni ve iyilik halini azaltabilmekte; bu da düşmelere odaklı rehabilitasyon stratejilerinin gerekliliğini ortaya koymaktadır.

Anahtar kelimeler: Çocuk, düşme, serebral palsy

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Introduction

Cerebral palsy (CP) is a complex neuromuscular disorder resulting from brain damage occurring during the prenatal, perinatal, or early postnatal period (1). Children with CP often develop spasticity, postural abnormalities, and abnormal gait patterns, which lead to balance problems and an increased frequency of falls (2). It has been reported that 35% of children with CP fall daily, while 30% fall weekly or monthly (3).

Falls may result in injuries that cause functional impairment, such as pain, dislocations, or fractures. Especially in childhood, psychosocial consequences such as embarrassment, social isolation, and depression may occur. When a child loses confidence in their ability to walk independently, their participation in daily activities decreases, negatively impacting quality of life (4,5).

Previous research has shown that children with typical neurodevelopment experience falls less frequently than those with CP (6). Due to motor and cognitive impairments, maintaining stability during gait becomes more difficult for children with CP, increasing their risk of falls (7). Studies have reported fall-related injury rates ranging from 31% to 82% in individuals with CP (8,9). Although most of these studies have been conducted in adults with CP, a recent study by Esterley et al. (10), which included both children and adults with CP, revealed that 55% of participants had experienced at least one fall resulting in serious injury. The same study also reported that children aged 5 to 12 years fell more frequently than other age groups (10).

Few studies have specifically compared the frequency and characteristics of falls between children with CP and healthy children. Most existing research focuses on adults or includes heterogeneous samples covering all age groups. Therefore, the aim of our study is to compare the frequency of falls, fall characteristics, and fall-related injuries between children with CP aged 5-12 years and age-matched healthy controls, within the age group reported to have the highest fall frequency.

Materials and Methods

This cross-sectional study included 23 children diagnosed with CP and 23 healthy children; all participants visited the Physical Medicine and Rehabilitation Outpatient Clinic at University of Health Sciences Turkey, İstanbul Physical Therapy and Rehabilitation Training and Research Hospital between December 10, 2024, and January 10, 2025. Informed consent was obtained from the parents

of all participants. Ethical approval for the study was obtained from the Ethics Committee of University of Health Sciences University of Health Sciences, İstanbul Physical Therapy and Rehabilitation Training and Research Hospital (protocol number: 2024-63, date: 05.12.2024). The study was conducted in accordance with the Declaration of Helsinki. This trial was registered at ClinicalTrials.gov (Identifier: NCT06679166).

Inclusion criteria were being between 5 and 12 years of age, being able to ambulate indoors and in the community, and having a caregiver able to communicate effectively. The 5-12 age range was selected to represent school-aged children, consistent with previous research examining fall frequency in ambulatory individuals with CP using similar age stratification (10). Exclusion criteria included refusal to participate, cognitive impairment, and neuromuscular disorders other than CP that could interfere with walking or increase the risk of falls. Children in the healthy control group were recruited from the outpatient clinic, from among those presenting with minor musculoskeletal complaints unrelated to mobilization or balance. None of the children had a known neurological disorder or condition affecting balance or gait.

At the beginning of the study, demographic data such as age, sex, height, weight, body mass index (BMI), and educational status were recorded. The caregiver's relationship to the child, caregiver's age and caregiver's educational level were also documented. Ambulation status, type of CP, use of assistive devices, presence of comorbidities, participation in rehabilitation, frequency of falls, and location and timing of falls were noted. Fall frequency was recorded from caregiver reports and initially categorized into frequency intervals (daily, weekly, monthly, and yearly). For further analysis, fall frequency was grouped according to the data distribution: Children experiencing up to 3-4 falls per month were classified as having lower fall frequency, and those with more frequent falls were classified as having higher fall frequency. This categorization was based on the sample distribution and was intended to facilitate comparisons between children with relatively low and high fall frequencies. The functional status of children with CP was assessed using the gross motor function classification system (GMFCS) and the functional ambulation classification (FAC) scale.

GMFCS

The GMFCS is a scale used to assess gross motor function in children with CP. It consists of five levels. Level I indicates minimal functional limitation, while level V represents the most severe functional limitation. Children

classified as level I can walk without restrictions and perform activities such as running and jumping, although they may experience limitations in speed, balance, and coordination. In contrast, children at level V are dependent even for basic movements such as head and trunk control (11). The GMFCS has been widely used in clinical and research settings, including studies conducted in the Turkish population (12,13).

FAC Scale

The FAC is a six-level scale used to evaluate the ambulation. It ranges from 0 to 5, with level 5 indicating independent ambulation on all surfaces and level 0 indicating non-functional ambulation (14). The FAC scale has been widely used in clinical practice and research to assess walking ability, including studies conducted in the Turkish population (15,16).

Sample Size

Sample size calculation was based on the reported fall frequency of 65% in children with CP (3) and 16.2% in healthy children (17). The required sample size for this study was calculated using G*Power software version 3.1.97 (Z-test). The effect size (Cohen's h) calculated from these proportions was 1.048. A 5% alpha level and 90% statistical power were used in the calculation. Accordingly, the minimum required sample size was determined to be 20 participants per group. To account for a potential dropout rate of 15%, 23 participants were included in each group.

Statistical Analysis

The normality of the data distribution was assessed using the Shapiro-Wilk test. Quantitative variables were summarized as mean $\pm$ standard deviation, median, and interquartile range, while categorical variables were presented as numbers and percentages. For comparisons between two independent groups, the independent samples t-test was used for normally distributed data, and the Mann-Whitney U test was applied for non-normally distributed data. Relationships between categorical variables were evaluated using the chi-square test. All statistical analyses were performed using IBM SPSS Statistics version 21.0 (IBM Corp., Armonk, NY, USA).

Results

Children included in the study were aged 5 to 12 years. The mean age was 8.11 ± 2.39 years in the CP group and 8.17 ± 1.83 years in the control group. There were no statistically significant differences between the groups in terms of age, sex, height, weight, BMI, or caregiver age. All participants were accompanied by their mothers. Comorbidities were less common in the healthy control group. Among children with CP, 26.09% had visual impairments, 8.7% had allergies, 13.04% had dysphagia, and 26.09% had spasticity. In the healthy control group, 20 children had no comorbidities, while 1 had an allergy, 1 had bronchitis, and 1 had phenylketonuria (Table 1).

Table 1. Descriptive statistics

		CP		Healthy controls		p-value
		Mean $\pm$ SD/n (%)	Median (IQR)	Mean $\pm$ SD/n (%)	Median (IQR)	
Age		8.11 $\pm$ 2.39	8 (4)	8.17 $\pm$ 1.83	8 (3)	0.918 ^t
Gender	Girls	8 (34.78%)		14 (60.87%)		0.077 ^x
	Boys	15 (65.22%)		9 (39.13%)		
Height		123.43 $\pm$ 17.82	120 (20)	129.78 $\pm$ 12.30	130 (17)	0.055 ^m
Weight		26 $\pm$ 11.06	25 (13)	29.74 $\pm$ 10.75	28 (13)	0.194 ^m
BMI		16.34 $\pm$ 3.10	17.16 (4.68)	17.21 $\pm$ 3.51	17.36 (5.17)	0.381 ^t
Caregiver age		35.04 $\pm$ 6.64	35 (7)	32.30 $\pm$ 3.75	32 (5)	0.146 ^m
Comorbidities	None	5 (21.74%)		20 (86.96%)		<0.001 ^f
	Visual impairment	6 (26.09%)		0 (0%)		
	PKU	0 (0%)		1 (4.35%)		
	Bronchitis	1 (4.35%)		1 (4.35%)		
	Allergy	2 (8.70%)		1 (4.35%)		
	Dysphagia	3 (13.04%)		0 (0%)		
	Spasticity	6 (26.09%)		0 (0%)		

CP: Cerebral palsy, BMI: Body mass index, PKU: Phenylketonuria, ^m: Mann-Whitney U test, ^t: Independent sample t-test, ^x: chi-square test, ^f: Fisher's exact test, IQR: Interquartile range, SD: Standard deviation

Among children diagnosed with CP, 91.3% reported experiencing at least one fall in the past six months, compared with 65.2% of healthy children. In the CP group, fall frequency was reported as 1-2 times per day in 21.7% of participants, 3-4 times per month in another 21.7%, and 1-2 times per year in 17.4% of participants. In the healthy group, approximately half of the participants (47.8%) reported falling 1-2 times per month, followed by 43.5% reporting falls 1-2 times per year. When fall frequency was grouped according to the data distribution, 43.5% of children with CP were classified in the higher-frequency group, whereas none of the healthy control children were.

Although most falls in both groups did not result in injury, the injury rate was marginally higher in the CP group. The majority of injuries were sprains, followed by contusions and pain. In the CP group, falls occurred more frequently at home, whereas outdoor falls were more common among healthy children. In both groups, falls were most commonly

reported in the afternoon. While 65.2% of falls in the healthy group occurred during running, the majority of falls in the CP group occurred during walking (Table 2).

When children with CP were analyzed by fall frequency, those in the higher-fall-frequency group were more often classified as GMFCS level II and included a higher proportion of children with spastic quadriplegia, whereas spastic diplegia was more common in the lower-fall-frequency group; however, these differences did not reach statistical significance. No statistically significant differences were observed between lower- and higher-fall-frequency groups in age, sex, BMI, caregiver education level, child's educational status, comorbidities, use of walking aids or orthotic devices, ambulation status, FAC scale level, rehabilitation frequency, or CP subtype (all $p>0.05$) (Table 3).

Table 2. Comparison of fall frequency, characteristics, and injury outcomes between children with cerebral palsy and healthy controls

		CP		Healthy controls		p-value
		n	%	n	%	
Fall in the last 6 months	Present	21	91.3	15	65.2	0.032 ^x
	Absent	2	8.7	8	34.8	
Fall frequency	1-2/day	5	21.7	0	0.0	<0.001 ^f
	3-4/day	2	8.7	0	0.0	
	5-6/day	1	4.3	0	0.0	
	3-4/week	2	8.7	0	0.0	
	1-2/month	2	8.7	11	47.8	
	3-4/month	5	21.7	1	4.3	
	1-2/year	4	17.4	10	43.5	
	3-4/year	2	8.7	1	4.3	
Fall frequency (grouped)	Lower	13	56.5	23	100	<0.001 ^x
	Higher	10	43.5	0	0	
Injury	None	9	39.1	13	56.5	0.050 ^f
	Pain only	4	17.4	7	30.4	
	Contusion	4	17.4	3	13.0	
	Sprain	6	26.1	0	0.0	
	Fracture	0	0.0	0	0.0	
Fall location	Home	7	30.4	0	0.0	<0.001 ^f
	School	1	4.3	7	30.4	
	Outdoors	5	21.7	16	69.6	
	Outdoors + school	3	13.0	0	0.0	
	Outdoors + indoors	4	17.4	0	0.0	
	Outdoors + bathroom	3	13.0	0	0.0	

Table 2. Continued

		CP		Healthy controls		p-value
		n	%	n	%	
Time of fall	Morning	1	4.3	2	8.7	0.132 ^f
	Noon	13	56.5	17	73.9	
	Morning + noon	3	13.0	0	0.0	
	Evening	2	8.7	4	17.4	
	Morning + evening	2	8.7	0	0.0	
	Noon + evening	2	8.7	0	0.0	
Activity during fall	Walking	10	43.5	0	0.0	<0.001 ^f
	Running	4	17.4	15	65.2	
	Sports	0	0.0	8	34.8	
	Bathroom	1	4.3	0	0.0	
	Walking + bathroom	1	4.3	0	0.0	
	Walking + sports	1	4.3	0	0.0	
	Running + sports	1	4.3	0	0.0	
	Walking + running	3	13.0	0	0.0	
	Running + bathroom	2	8.7	0	0.0	

CP: Cerebral palsy, ^x: Chi-square test, ^f: Fisher's exact test

Table 3. Comparison of demographic and clinical characteristics by fall frequency in children with cerebral palsy

		Lower fall frequency		Higher fall frequency		p-value
		n/mean ± SD	%	n/mean ± SD	%	
Gender	Female	5	38.5	3	30.0	1.000 ^x
	Male	8	61.5	7	70.0	
Age		8.27±2.47		7.9±2.39		0.722 ^t
BMI		16.33±3.40		16.36±2.84		0.980 ^t
Caregiver education	Illiterate	3	23.1	0	0.0	0.517 ^f
	Primary school	2	15.4	4	40.0	
	Secondary school	3	23.1	2	20.0	
	High school	3	23.1	3	30.0	
	University	2	15.4	1	10.0	
Child's education	None	1	7.7	3	30.0	0.183 ^f
	Special education	5	38.5	2	20.0	
	Preschool	0	0.0	2	20.0	
	Primary school	5	38.5	1	10.0	
	Secondary school	2	15.4	2	20.0	
Comorbidities	None	3	23.1	2	20.0	0.773 ^f
	Visual impairment	4	30.8	2	20.0	
	Bronchitis	0	0.0	1	10.0	
	Allergy	2	15.4	0	0.0	
	Dysphagia	1	7.7	2	20.0	
	Spasticity	3	23.1	3	30.0	
Rehabilitation frequency	None	1	7.7	0	0.0	0.469 ^f
	Daily	4	30.8	4	40.0	
	2-3 times/week	8	61.5	4	40.0	
	Once/6 months	0	0.0	1	10.0	
	2-3 times/month	0	0.0	1	10.0	

Table 3. Continued

		Lower fall frequency		Higher fall frequency		p-value
		n/mean $\pm$ SD	%	n/mean $\pm$ SD	%	
Walking aid	None	9	69.2	6	60.0	0.803 ^f
	Walker	3	23.1	4	40.0	
	Reverse walker	1	7.7	0	0.0	
Orthotic device	None	5	38.5	2	20.0	0.619 ^f
	AFO	7	53.8	7	70.0	
	KAFO	0	0.0	1	10.0	
	GRAFO	1	7.7	0	0.0	
CP type	Spastic diplegia	8	61.5	4	40.0	0.797 ^f
	Spastic quadriplegia	2	15.4	3	30.0	
	Ataxic	1	7.7	1	10.0	
	Hemiplegic	2	15.4	2	20.0	
Ambulation	Household	4	30.8	3	30.0	1.000 ^x
	Community	9	69.2	7	70.0	
GMFCS	Level I	4	30.8	3	30.0	0.685 ^f
	Level II	4	30.8	5	50.0	
	Level III	5	38.5	2	20.0	
FAC scale	Level II	1	7.7	1	10.0	0.474 ^f
	Level III	3	23.1	0	0.0	
	Level IV	5	38.5	6	60.0	
	Level V	4	30.8	3	30.0	

AFO: Ankle-foot orthosis, KAFO: Knee-ankle-foot orthosis, GRAFO: Ground reaction ankle-foot orthosis, GMFCS: Gross motor function classification system, FAC: Functional ambulation classification, SD: Standard deviation, ^x: Chi-square test, ^f: Fisher's exact test

Discussion

In this study, the frequency of falls and their relationships with demographic and disease-specific characteristics were investigated in children aged 5 to 12 years with CP compared with healthy controls. The study found that 91.3% of children with CP and 65.2% of healthy children experienced at least one fall in the past six months. In the CP group, the majority of falls occurred at home and while walking. Although no severe injuries were reported following the falls, most of the injuries were sprains.

Most studies have focused on the general CP population or on adult patients, whereas few specifically evaluate pediatric CP populations. A large-scale study reported that individuals with CP fell significantly more often than those without CP, with a 3.6-fold higher likelihood of falling and approximately a sixfold higher fall rate (18). In the study by Esterley et al. (10), which included individuals with CP aged between 5 and 76 years, 86% were reported to have fallen within the past 12 months. Among children, this rate was 89%, and the age group with the highest fall frequency

during both the past 30 days and 12 months was 5-12 years (10). In another study by Alemdaroğlu et al. (19), involving 93 children with CP aged 3 to 18 years receiving inpatient rehabilitation, 27% were reported to have fallen during hospitalization. Among the 42 children who were able to stand, 16 had experienced falls (19).

Previous studies evaluating falls in ambulatory individuals with CP have used comparable age groupings, including a 5-12-year category, and reported higher fall frequency in this group (10). Nevertheless, the transition to adolescence (10-12 years) involves growth-related changes that may influence balance. The literature presents conflicting findings on this issue. One study reported a higher incidence of distal radius fractures during the adolescent growth spurt (20). Another study suggested that during periods of rapid growth in adolescence, individuals' ability to integrate proprioceptive inputs may be reduced (21). Although pubertal status was not assessed in the present study, this potential confounding effect should be considered when interpreting the findings.

Boyer and Patterson (3) reported that 35% of children with CP had never fallen, 35% fell daily, and 30% fell weekly or monthly. Moreover, younger children were found to fall more frequently (3). Similarly, in the study by Alemdaroğlu et al. (19), the mean age of children who fell during hospitalization was significantly lower. However, when children who were able to stand were analyzed separately, the mean age did not differ significantly between fallers and non-fallers. In our study, we also evaluated ambulatory children, and the mean ages of those with higher and lower fall frequencies were similar.

In the study by Esterley et al. (10), fall frequency was shown to vary according to GMFCS levels. Specifically, among children aged 5-12 years, those at GMFCS level II were found to fall more frequently (10). Similarly, Boyer and Patterson (3) reported that among 1063 children with CP, the highest fall frequency was observed in those at GMFCS level II. This trend is also noted in adult CP populations, where individuals classified as GMFCS level II appear to fall more frequently than those at other levels (22). In our study, 50% of the children classified as having a higher fall frequency were at GMFCS level II; however, this difference did not reach statistical significance, which may be attributable to the relatively small sample size.

In our study, no serious injuries following falls were reported in either the CP or control group. Among the CP group, 9 children reported no injury, while 4 reported only pain, 4 had contusions, and 6 experienced sprains, all of which were considered minor injuries. No cases of fractures were recorded. In contrast, the study by Esterley et al. (10) reported that 55% of participants had experienced at least one serious injury due to a fall, with such injuries being more common in older age groups. Furthermore, among children aged 5-12 years, those at GMFCS level II had approximately twice the rate of fall-related serious injuries compared to other levels (10).

In our study, most falls among children with CP occurred while walking, whereas most falls among healthy children occurred while running. Similarly, Morgan et al. (8) reported that 55% of falls in adults with CP occurred during walking. Esterley et al. (10) also found that over 75% of falls took place during ambulation. In our study, 43.5% of falls reported over the past six months occurred during walking, 17.4% during running, 13% during combined walking and running, and 8.7% during running and bathroom activities. These findings are consistent with previous literature. In addition, our study showed that children with CP most frequently experienced falls in the home environment. The

finding that falls most commonly occur at home and during ambulation has important clinical implications. Simple home modifications may help reduce the risk of falls in ambulatory children with CP. These may include removing environmental obstacles such as loose rugs and electrical cords, ensuring adequate lighting, using non-slip flooring or mats, and installing handrails or grab bars in areas such as stairs and bathrooms. Furthermore, encouraging the use of appropriate footwear and maintaining clear walking pathways within the home environment may further support safer ambulation (23). Providing families with practical guidance on home safety may therefore play an important role in fall prevention.

Study Limitations

This study has both limitations and strengths. It is among the few studies that specifically examine fall frequency and characteristics in pediatric patients with CP. One of its strengths is the inclusion of a healthy control group for comparison. The sample size was determined based on power analysis; however, it may still be considered relatively small and thus represent a limitation. Another important limitation is that fall-related data were based entirely on caregiver reports, which may introduce recall bias, particularly regarding the frequency and timing of falls. As a result, fall frequency may have been under- or overestimated in some participants, and the observed associations should therefore be interpreted with caution. In addition, the study was conducted at a single center, which may limit the generalizability of the findings. Future studies should include larger, multicenter samples and adopt prospective or longitudinal follow-up designs to more accurately capture fall frequency and related characteristics.

Conclusion

This study demonstrates that children with CP aged 5-12 years fall significantly more often than their healthy peers. While the majority of falls in the CP group occurred during walking, those in the healthy group were more common during running activities. Although most falls in our study resulted in minor injuries such as sprains, contusions, and pain, previous studies have reported fractures and major injuries that can lead to significant functional limitations. Furthermore, falls may negatively impact children's quality of life and psychosocial well-being. These findings emphasize the high risk of falls in children with CP and the need for effective rehabilitation strategies to prevent falls.

Ethics

Ethics Committee Approval: Ethical approval for the study was obtained from the Ethics Committee of University of Health Sciences Turkey, İstanbul Physical Therapy and Rehabilitation Training and Research Hospital (protocol number: 2024-63, date: 05.12.2024).

Informed Consent: Informed consent was obtained from the parents of all participants.

Footnotes

Authorship Contributions

Concept: B.Ş.A., N.P., N.K., Design: B.Ş.A., N.P., N.K., D.B., Data Collection or Processing: B.Ş.A., N.K., D.B., Analysis or Interpretation: D.B., Y.S.Ö. Literature Search: B.Ş.A., N.P., Y.S.Ö. Writing: B.Ş.A.

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