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How does attention deficit hyperactivity disorder affect children's road-crossing? A case-control study

Zahra Tabibi[a,b] , David C. Schwebel[c] , and Mahboobeh Hashemi Juzdani[a]

[a]Department of Psychology, Ferdowsi University of Mashhad, Mashhad, Iran; [b]Department of Community Health Sciences, Faculty of Medicine and Health Sciences, University of Sherbrooke, Longueuil, Canada; [c]Department of Psychology, University of Alabama at Birmingham, Birmingham, Alabama, USA

ABSTRACT

Objective: Children diagnosed with attention-deficit/hyperactivity disorder (ADHD) may have particularly high pedestrian injury risk given their deficits in attention, inhibition, and concentration. The aims of this study were a) to assess differences in pedestrian skill between children with ADHD and typically-developing children and b) to examine relations between pedestrian skill and attention, inhibition, and executive function among children with ADHD as well as among typically-developing children.

Methods: A sample of 50 children with mean age of 9 years participated, 56% of them diagnosed with ADHD. Children completed IVA + Plus, an auditory-visual test evaluating impulse response control and attention and then engaged in a Mobile Virtual Reality (MVR) pedestrian task to assess pedestrian skills. Parents completed the Barkley's Deficits in Executive Functions Scale-Child & Adolescents (BDEFS-CA) to rate children's executive function. Children with ADHD engaged in the experiment off any ADHD medications.

Results: Independent samples *t*-tests indicated significant differences between the two groups in all IVA + Plus and BDEFS_CA scores, supporting the clinical diagnoses of ADHD and the distinction between the two groups. Independent samples *t*-tests also indicated differences in pedestrian behavior: Children in the ADHD group had significantly higher numbers of unsafe crossings in the MVR environment. Partial correlations within samples stratified by ADHD status indicated that for both groups of children, there were positive correlations between unsafe pedestrian crossings and executive dysfunction. There were no relations between IVA + Plus attentional measures and unsafe pedestrian crossings in either group. A linear regression model predicting unsafe crossings was significant, with children with ADHD more likely to cross in a risky manner after controlling for executive dysfunction and child age.

Conclusions: ADHD children exhibited riskier street-crossing behavior in the MVR, confirming an increased risk of pedestrian injury among children with ADHD compared to typically-developing children. Risky crossing among the typically-developing children and ADHD was related to deficits in executive function. Implications are discussed in relation to parenting and professional practice.

Introduction

Child and adolescent transport-related injuries and fatalities represent a major global public health issue (WHO 2018). Children are particularly vulnerable as pedestrians, partly because their capacity to engage with traffic is underdeveloped (Tabibi and Pfeffer 2003; Thomson 1996) and partly because all pedestrians lack the protection of vehicle passengers.

The risk of child pedestrian injury varies across countries. In Iran, a middle-income country where the current research was conducted, the rate of road traffic injuries (RTI) is much higher than the worldwide rate (WHO 2018) and accounted for 35.6 age-standardized deaths per 100000 in 2016 (Bazargan-Hejazi et al. 2018). The burden was disproportionately higher among children (Naghavi et al. 2009;

Bazargan-Hejazi et al. 2018), who were more likely to be killed as pedestrians (15.0% of total RTI death among Iranian children) (Bazargan-Hejazi et al. 2018). Thus, children are the most vulnerable road user in Iran as pedestrians (Roudsari et al. 2006; Bazargan-Hejazi et al. 2018).

Children and adolescents with attention-deficit/hyperactivity disorder (ADHD) are overrepresented both in broad injury rates (Maxson et al. 2009; Newcorn 2015; Ruiz-Goikoetxea et al. 2018; Tai et al. 2013; Liou et al. 2018) and among RTI victims (Nikolas et al. 2016), having three to four times more injuries than their typically-developing peers (Barkley 2002).

Previous research suggests children with ADHD may have elevated injury rates because their symptoms of inattention, hyperactivity, and/or impulsivity impede their cognitive decision-making in situations like engaging in

traffic (Barkley 2002; Epstein et al. 2003; Huang-Pollock et al. 2012; Lansbergen et al. 2007; Willcutt et al. 2005). Specifically, children with ADHD have deficits in executive function skills, including inhibitory processes and attentional processes, that are essential to engaging in safe pedestrian behavior (Schwebel et al. 2008; Schwebel et al. 2017; Tabibi and Pfeffer 2003, 2007; Tabibi et al. 2012).

The scope of previous research considering the impact of ADHD symptoms on child pedestrian behavior is rather limited. In an unpublished thesis, Toye (2016) assessed hazard perception abilities, visual gap timing and road user intentions among medicated and unmedicated children diagnosed with ADHD. They found that stimulant medication improved children's pedestrian skills. In a different study, Stavrinos and colleagues demonstrated poor decision-making among unmedicated children with ADHD when they initiated street-crossing within a virtual pedestrian environment compared to typically-developing children (Stavrinos et al. 2011). That study also showed that children with ADHD selected smaller gaps to cross within, had a smaller safety margin with oncoming traffic, and experienced more virtual collisions. However, they reported no differences between the groups in curbside behavior, including looking at traffic and time waiting to cross. Similar results were reported among a sample of adolescents (Clancy et al. 2006) and a recent study of children with ADHD in Iran (Tabibi et al. 2022). All reports speculate that deficits in executive functions among children and adolescents with ADHD may impact children's decision-making at road crossings, but only Stavrinos et al. (2011), among a sample of American children ages 7 to 10 years, assessed executive function in the sample of children.

The present paper aims to replicate and extend those previous findings by examining pedestrian skills and executive functions among children diagnosed with ADHD and matched, typically-developing controls. These data add to the scant research literature on pedestrian skills of children diagnosed with ADHD through rigorous study of both executive function and pedestrian behavior among a sample of children in Iran, a middle-income country. Pedestrian behavior was assessed using a virtual reality simulation. Executive function was assessed through both parent-report and computer-based testing. We considered four primary hypotheses: (1) Children with ADHD will perform more poorly on response control and attention tasks than typically-developing children, validating the accuracy of the ADHD diagnoses; (2) Children with ADHD will score lower in executive functions than typically-developing children, validating the accuracy of the ADHD diagnoses; (3) Children with ADHD will perform in a riskier manner than typically-developing children when crossing a virtual street, as manifested by higher number of hits and close calls with virtual traffic, lower frequency of looking left and right at traffic, and shorter start delays to enter safe traffic gaps compared to typically-developing children; and (4) Executive dysfunction and response control and attention will be associated with riskier pedestrian behavior both among typically developing children and among children with ADHD. Given the deficits in executive function and response control and

attention for children with ADHD and the developmental stage for typical-developing children, we expected that the relation between executive function and risky pedestrian behavior would be stronger among children with ADHD than for typically-developing children

Methods

Participants

A total of 50 children (28 diagnosed with ADHD, 22 typically-developing) aged 7–12 years participated in the study. Children with ADHD were recruited from pediatric/family practice clinics in two cities in Iran, Mashhad and Isfahan. ADHD diagnoses were made by either a licensed child psychiatrist or child clinical psychologist. The diagnosis was based on the diagnostic criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition, Text Revision (American Psychiatric Association 2013). Children who exhibited intellectual or other disabilities that prevented the child from understanding the study protocol or questionnaires were excluded. The sample of children with ADHD was 50% girls and had a mean age of 9.00 years (SD = 1.29). All children were being treated with family and child psychotherapy and none were treated with medication.

Children without ADHD were recruited as a control group via advertisements and through families referred to the clinic for other reasons. Children who showed no evidence of any clinical disorder based on a brief clinical interview and parent report of a normal developmental history were invited to participate in the study. The sample of 22 typically developing children had a mean age of 9.92 years (SD = 1.69). They were 45.5% girls.

All study protocols were completed in the clinics. The research proposal was approved by Ferdowsi University of Mashhad's Institutional Review Board prior to commencement of data collection, all parents provided informed consent and all children provided assent to participate.

Protocol

Children participated individually in a single experimental session. Following informed consent procedures, children were taken into a room to perform the IVA + Plus and then the MVR. Both tasks included a "practice" segment to familiarize children with the task before data collection began. While children were engaged in those assessments, parents completed the Deficits in Executive Functioning Scale for Children and Adolescents. Details about each task appear below.

Instruments

The virtual reality pedestrian environment

The study used a mobile smartphone-based virtual reality (MVR) previously developed and validated by Schwebel et al. (2008) and Schwebel et al. (2017). The smartphone-based VR hardware consisted of a REDMI NOT3 smartphone with 2 GB RAM, 32 GB internal memory capacity,

HEXA-CORE MAX1.8 GHZ CPU. From a software perspective, the MVR provides an immersive and interactive virtual pedestrian environment that replicates an actual crosswalk near a local school and shows a midblock crossing on a two-lane bidirectional road marked with a crosswalk. Children view traffic moving from both directions and press a button when they believe it is safe to cross. By pressing the button, the child initiates the street crossing at a walking speed typical for child pedestrians. As the child watches from a first-person perspective, the virtual traffic environment remained and cars continued to move in both directions, allowing the child to experience the success (or failure) of their crossing. Positive feedback was provided for safe crossings, and cautionary feedback for collisions and close calls (within 1 second of a collision).

Participants completed 21 street crossings in the MVR task, 7 at each of three levels of difficulty in terms of traffic speed and volume/density. As detailed elsewhere (Schwebel et al. 2017), cars in the MVR appear at random intervals pre-determined by the device and move at constant speeds. We considered three outcome measures related to pedestrian safety: (a) number of unsafe pedestrian crossings, conceptualized as when the pedestrian was struck by a virtual vehicle (a hit) or was within 1 s of being struck (close calls); (b) start delay, which refers to the latency between the traffic gap appearing and the onset of child's attempt to cross; (c) attention to traffic, conceptualized as the proportion of looks to the left plus looks to the right divided over the time waiting to cross the street (Schwebel et al. 2017).

IVA + plus test (BrainTrain, Inc., North Chesterfield, VA) (Sandford and Turner 1995)

The IVA + Plus Test is a continuous auditory-visual test evaluating two cognitive functions, impulse response control and attention. The IVA + Plus is a 13-minute test. To complete the test, children respond to about 500 test stimuli, each presented for 1.5 s, by pressing a computer mouse as quickly as possible when the target stimuli appears, either visually or aurally. The test provides scaled scores as outcomes with a mean of 100 and a standard deviation of 15. We considered three outcome scale scores: response control, sustained attention and focused attention. This task was not administered for 10 participants (8 with ADHD) due to unavailability of the task.

Deficits in executive functioning scale for children and adolescences (BDEFS-CA; Barkley 2011)

Parents completed this 70 item questionnaire concerning their children's executive function. The instrument produces five subscales based on children's executive functioning in everyday life activities: self-time management, self-organization/problem solving, self-control/inhibition, self-motivation, emotional self-regulation. The scale is validated for both clinical and non-clinical use. We considered total score of deficits in executive functions. The validity and reliability of this questionnaire has been established for Iranian children and adolescents (Mashhadi et al. 2021).

Results

First, we examined the normality of variables using a one-sample Kolmogorov-Smirnov test. Some were above 0.05, so, results were double checked with non-parametric tests. Next, we considered differences between the two groups. Independent samples t-tests showed that the groups varied in age (Mean$_{ADHD}$= 9.00, SD = 1.29; Mean$_{TD}$ = 9.92, SD = 1.69; t(48)= −2.19, p < 0.05) but were similar in terms of gender composition (54% boys, 46% girls) (ADHD: boy = 15, Girl= 13; TD: boy = 12, girl = 10; x^2 = .78, p>.05). Age was controlled, therefore, in subsequent analyses involving both groups.

Descriptive data for the IVA+, BDEFS-CA and MVR are presented in Table 1.

We used independent samples t-tests to test our primary hypotheses. As shown in Table 1, the groups varied on all executive function outcomes. Compared to typically-developing children, children with ADHD had significantly lower scores on the IVA + in sustained attention, focused attention and response control. They also had higher scores on the BDEFS-CA in total score of deficits in EF compared to typically-developing children. In sensitivity analyses adjusting for child age using multivariate analysis of co-variance and univariate analysis of co-variance, with age included as a covariate, results were similar.

Pedestrian safety outcomes were mixed. Children with ADHD had significantly more unsafe crossings in the MVR environment, but there were no significant group differences in the number of looks toward traffic per minute or in start delay to enter into the traffic after a safe gap appeared. Sensitivity analyses (multivariate analysis of co-variance and univariate analysis of co-variance) with age as covariate yielded similar results.

Next, a partial correlation with child age partialed was computed to assess relations between the variables separately for each group of children. Results are presented in Table 2. As shown, among children with ADHD the total score of BDEFS-CA related to unsafe crossings (r=.54). For typically developing children, the number of unsafe crossings was also significantly and positively related to higher scores in total score of deficits in executive functions (r=.43, p<.05). Since the sample size was different for each group, a comparison between correlation coefficients (r=.54 vs r=.43) was computed to see if the strength is different. No significant difference was observed (z=.43, p>.05). Furthermore,

Table 1. Means and standard deviations for IVA+, BDEFS-CA and MVR variables.

		ADHD		TD		
		Mean	(SD)	Mean	(SD)	t(48)
IVA+[a]	Sustained attention	70.49	13.39	80.90	10.00	−2.80*
	Focused attention	66.53	11.77	81.60	10.65	−4.25***
	Response control	63.74	14.59	83.75	10.10	−5.05***
BDEFS-CA	DEF (total)	179.57	50.09	114.95	27.78	5.77***
MVR	Unsafe crossing (count)	12.25	3.04	7.00	3.90	5.41**
	Looking left/right (ratio)[b]	.56	.29	.79	.53	−1.98
	Start-delay (sec)	2.28	.82	1.96	.71	1.43

Note: *p<.05. **p<.01. ***p<.001. TD = typically developing; DEF = deficits in executive functions.
[a]df = 38.
[b]Total number of looking divided by wait time.

Table 2. Partial correlation coefficients between IVA+, BDEFS-CA and MVR variables by each group, with age as the controlling variable.

| | MVR | | | IVA + Plus | | | BDEFS-CA |
	1	2	3	4	5	6	7
1. Unsafe crossing	1	.07	−.07	.00	−.06	.03	.54**(df = 25)
2. Start delay	−.07	1	−.60***	.21	.33	.33	−.05
3. Looking left/right (ratio)	.05	−.10	1	−.06	−.37	−.11	.14
IVA + Plus							
4. Sustained attention	.02	−.25	−.31	1	.82***	.64***	.03
5. Focused attention	.10	−.16	.33	.05	1	.65***	−.08
6. Response control	.40	.06	−.03	.33	.47*	1	.05
BDEFS-CA							
7. DEF	.43*(df = 19)	−.22	.28	.27	.40	.27	1

Note: Upper diagonal = ADHD; lower diagonal = TD. ***p<.001. **p<.01. *p<.05

Table 3. Linear regression predicting unsafe crossing by independent variables of age (control variable), group, DEF and group*DEF.

	β1	β2	β3
Age	−.57***	−.61***	−.61***
group	.44***	.19*	.23
DEF		.39***	.42*
Group* DEF			−.07

Note: ***p<.001. **p<.01. *p<.05

none of the IVA + measures correlated significantly to unsafe crossings in either group.

Next, t linear regression was used to predict the number of unsafe crossing, by group, child age, the BDEFS-CA, and the interaction of group * BDEFS-CA. The regression was constructed using three steps. In the first model, only age and group were entered. The overall model was significant (R^2= .68, $F(2,47)$= 50.47, p<.001), and both age and group were significant predictors ($\beta = -.57$ & $\beta = .44$ respectively, all ps<.001). In the second model, BDEFS-CA was added also as a predictor. The overall model was significant (R^2= .77, $F(3,46)$= 52.88, p<.001) and age, group and BDEFS-CA all emerged as significant predictors (β= −.61, p<.001; β= .19, p<.05; β= .39, p<.001 respectively). Inclusion of BDEFS-CA in the model added 9% to the variance accounted for (R^2_{change} =.09, $F(1,46)$=18.99, p<.001). In the third model, the group*BDEFS-CA interaction effect was added to the model. The overall model remained significant (R^2= .77, $F(4,45)$= 38.81, p<.001), but the interaction effect was not significant (see Table 3).

Discussion

The current study aimed to examine how children diagnosed with ADHD may differ from typically-developing children in pedestrian behavior, and whether executive function may contribute to pedestrian safety both among children with ADHD and among typically-developing children. Given the deficits children with ADHD often have in executive functions like attention and inhibition, we hypothesized children with ADHD may experience greater risk in pedestrian settings and that their executive function skills would correlate to pedestrian skills.

Our results regarding executive functions were as hypothesized: children with ADHD scored more poorly than typically developing children in their ability to focus attention, sustain attention and control responses (Doyle 2006).

They also were reported by their parents as exhibiting higher deficits in all executive functions on the BDEFS-CA.

Of greater interest, compared to typically-developing children, children with ADHD exhibited significantly higher numbers of unsafe crossings in the simulated pedestrian task. This result confirms prospective and retrospective studies in a number of countries indicating the vulnerability to injuries among children with ADHD compared to typically-developing children (Tai et al. 2013; Maxson et al. 2009; Bonander et al. 2016; Dalsgaard et al. 2015a,b; Wamithi et al. 2015). It also replicates one previous study using a semi-immersive, interactive, virtual pedestrian environment, which found that children with combined type of ADHD chose riskier pedestrian environments to cross within than typically-developing children (Stavrinos et al. 2011).

Although children with ADHD made riskier street crossings, our examination of the components of pedestrian behavior did not always yield significant differences between the two groups of children. Children with ADHD behaved similar to typically-developing children in the number of looks to the left and right before starting to cross. Looking for traffic does not necessarily suggest processing of stimuli was similar, however. Although head movement behavior is strongly related to safer behavior in traffic situations, moving one's head to look right and left does not necessarily indicate all relevant information is noticed and processed (van der Molen 1981; Whitebread and Neilson 2000; Tabibi and Pfeffer 2003). Typically developing children may look at traffic and then utilize the information efficiently to make safe crossing decisions whereas children with ADHD may experience symptom-related deficits in perceiving and processing the visual stimuli they view. An alternative explanation of the null results on looking left and right is that all children are taught from a very young age to "look both ways" when they cross a street, and therefore looking at traffic may be automatic for all children. Again, children with ADHD may look at traffic but not process it efficiently or capably. Further studies are recommended to investigate exactly how children with ADHD explore visual fields compared to typically-developing children, and to probe how these explorations might affect road crossing decisions and safety.

We also found that children with ADHD took a similar amount of time to enter the roadway after a safe gap was present compared to typically developing children. This start delay result is consistent with previous results (Stavrinos et al. 2011) and may indicate children with ADHD have

deficits in selecting safe gaps to cross within, but once they select a gap they process and enter that gap in a manner similar to typically-developing children. Alternatively, the non-significance of start delay might be due to the composition of the sample of children with ADHD, as we did not limit our sample to particular subtypes (i.e., inattentive, hyperactive-impulsive, or combined type). It might be that inattentiveness relates to longer start delays while hyperactive and impulsive symptoms are related to shorter start delays (Tabibi and Pfeffer 2003). This speculation is supported by results examining road crossing in another modality, bicycling (Nikolas et al. 2016), where hyperactivity-impulsivity was associated with a shorter start delay. Further investigation is recommended.

We also considered how executive functions and pedestrian outcomes intercorrelated among the two groups of children. The correlation between unsafe crossing and deficits in executive functions was significant among children with ADHD as well as among the typically-developing children; those with more unsafe street crossings had higher deficits in executive functions. Further analysis using linear regression showed that when the variance in age and deficits in executive functions were taken into account, children with ADHD took more unsafe crossings than typically-developing children but the interaction between group and deficits in executive function was not significant. These results suggest that for both typically-developed children and children with ADHD, deficits in executive functions increase unsafe crossing behavior. However, there might be some aspect of ADHD symptomatology beyond executive functioning that place them at risk of dangerous pedestrian behaviors, as group status predicted unsafe crossing even after controlling for executive function skills. One possible explanation is the process by which children with ADHD process information in traffic (Tabibi et al. 2022).

Pedestrian measures were not related to sustained, focused attention or control of responses, as measured by IVA+, in either group. This may suggest the type of attention and inhibition assessed by IVA+ is not relevant to the attentional and inhibitory skills pertinent to the safe pedestrian behavior. Alternatively, attentional processes may be automated in pedestrian settings by the target age group, and therefore less relevant to children's pedestrian safety in either of the groups studied. These results may also suggest the higher precision of parent report on rating scales concerning executive function skills associated with children's pedestrian safety.

The current study offers novel information to explain riskier pedestrian behaviors among children with ADHD, given the results that: a) executive dysfunction was associated with unsafe pedestrian crossings among both typically-developing children and children with ADHD, and b) after controlling for child age and executive dysfunction, children with ADHD experienced more unsafe crossings than typically-developing children. We may conclude that underdeveloped executive function appears to contribute to risky pedestrian behavior among children with ADHD (Stavrinos et al. 2011) and that natural development of executive functions in childhood contributes to age-related improvements in street crossing safety (Tabibi and Pfeffer 2003, 2007; Barton and Schwebel 2007).

Our study had several limitations. First, the sample size was relatively small, leading to diminished statistical power in our analyses. This is complicated by the fact that several children with ADHD had missing data for the IVA + Plus test. Second, we did not consider subtypes of ADHD children (inattentive type, hyperactive-impulsive type, and combination type), a detail that is relevant considering evidence suggesting that there is neurocognitive heterogeneity in components of executive functions among ADHD children (Kofler et al. 2019). Future research should work to better characterize this heterogeneity and its implications for children's road safety. Third, our two groups of children were statistically different in terms of child age. We controlled for age in all relevant analyses, but future research might strive to match groups more accurately by age. Last, we assessed visual aspects of pedestrian behavior through children's looking left and right but skilled pedestrians must both look at traffic and also listen to it from both directions before stepping out into the road (Sandels 1970; Vinje 1981). Therefore, future research might consider strategies to assess children's listening to traffic stimuli as well as visual behavior during street-crossing, both among children with ADHD and typically-developing children.

In conclusion, this study suggests that when children with ADHD are unmedicated and exposed to traffic, they are at higher risk of injury than typically developed children. Underdeveloped executive function may partially explain the increased risk. Practitioners should be cognizant of these increased risks and inform parents about relevant interventions that might help children stay safe in traffic. Parents also should be aware of the increased vulnerability among children with ADHD and supervise their children carefully. Educators might consider strategies to tailor training programs for children with ADHD, perhaps through use of virtual reality programs.

ORCID

Zahra Tabibi http://orcid.org/0000-0002-5648-9533
David C. Schwebel http://orcid.org/0000-0002-2141-8970

Data availability statement

Data will be available from the corresponding author upon reasonable request.

References

American Psychiatric Association. 2013. Diagnostic and statistical manual of mental disorders. 5th ed. Arlington (VA): American Psychiatric Association. doi: https://doi.org/10.1176/appi.books.9780890425596.

Barton BK, Schwebel DC. 2007. The roles of age, gender, inhibitory control, and parental supervision in children's pedestrian safety. J Pediatr Psychol. 32(5):517–526.

Barkley RA. 2002. Major life activity and health outcomes associated with attention deficit/hyperactivity disorder. J Clin Psychiatry. 63(12): 12–15.

Barkley RA. 2011. Barkley Deficits in Executive Functioning Scale (BDEFS). New York (NY): Guilford Press.

Bazargan-Hejazi S, Ahmadi A, Shirazi A, Ainy E, Djalalinia SH, Fereshtehnejadet SM, et al. 2018. The burden of road traffic injuries in Iran and 15 surrounding countries: 1990–2016. Arch Iran Med. 21(12):556–565.

Bonander C, Beckman L, Janson S, Jernbro C. 2016. Injury risks in schoolchildren with attention-deficit/hyperactivity or autism spectrum disorder: results from two school-based health surveys of 6- to 17-year-old children in Sweden. J Safety Res. 58:49–56. doi: 10.1016/j.jsr.2016.06.004

Clancy TA, Rucklidge JJ, Owen D. 2006. Road-crossing safety in virtual reality: a comparison of adolescents with and without ADHD. J Clin Child Adolesc Psychol. 35(2):203–215. doi: 10.1207/s15374424jccp3502_4

Dalsgaard S, Leckman JF, Mortensen PB, Nielsen HS, Simonsen M. 2015. Effect of drugs on the risk of injuries in children with attention deficit hyperactivity disorder: a prospective cohort study. Lancet Psychiatry. 2(8):702–709. doi: 10.1016/S2215-0366(15)00271-0

Dalsgaard S, Østergaard SD, Leckman JF, Mortensen PB, Pedersen MG. 2015. Mortality in children, adolescents, and adults with attention deficit hyperactivity disorder: a nationwide cohort study. Lancet. 385(9983):2190–2196. doi: 10.1016/S0140-6736(14)61684-6

Doyle AE. 2006. Executive functions in attention-deficit/hyperactivity disorder. J Clin Psychiatry. 67(8):21–26.

Epstein JN, Erkanli A, Conners CK, Klaric J, Costello JE, Angold A. 2003. Relations between continuous performance test performance measures and ADHD behaviors. J Abnorm Child Psychol. 31(5): 543–554. doi: 10.1023/a:1025405216339

First MB, Williams JBW, Karg RS, Spitzer RL. 2016. User's guide for the SCID-5-CV structured clinical interview for DSM-5® disorders: clinical version.

Huang-Pollock CL, Karalunas SL, Tam H, Moore AN. 2012. Evaluating vigilance deficits in ADHD: a meta-analysis of CPT performance. J Abnorm Psychol. 121(2):360–371. doi: 10.1037/a0027205

Kofler MJ, Irwin LN, Soto EF, Groves NB, Harmon SL, Sarver DE. 2019. Executive functioning heterogeneity in pediatric ADHD. J Abnorm Child Psychol. 47(2):273–286. doi: 10.1007/s10802-018-0438-2

Lansbergen MM, Kenemans JL, van Engeland H. 2007. Stroop interference and attention-deficit/hyperactivity disorder: a review and meta-analysis. J Neuropsychol. 21(2):251–262. doi: 10.1037/0894-4105.21.2.251

Liou YJ, Wei HT, Chen MH, Hsu JW, Huang KL, Bai YM, Su TP, Li CT, Yang AC, Tsai SJ, et al. 2018. Risk of traumatic brain injury among children, adolescents, and young adults with attention-deficit hyperactivity disorder in Taiwan. J Adolesc Health. 63(2):233–238. doi: 10.1016/j.jadohealth.2018.02.012

Mashhadi A, Maleki ZH, Hasani J, Rasoolzadeh, Tabatabaei SK. 2021. Psychometric properties of Persian version of the Barkley deficits in executive functioning scale–children and adolescents. Appl Neuropsychol Child. 10(4):369–376. doi: 10.1080/21622965.2020.1726352

Maxson RT, Lawson KA, Pop R, Yuma-Guerrero P, Johnson KM. 2009. Screening for attention-deficit/hyperactivity disorder in a select sample of injured and uninjured pediatric patients. J Pediatr Surg. 44(4):743–748. doi: 10.1016/j.jpedsurg.2008.08.003

Naghavi M, Abolhassani F, Pourmalek F, Lakeh M, Jafari N, Vaseghi S, Mahdavi Hezaveh N, Kazemeini H. 2009. The burden of disease and injury in Iran 2003. Popul Health Metr. 7:9.

Newcorn JH. 2015. Medication for ADHD and accidental injury. Lancet Psychiatry. 2(8):669–671. doi: 10.1016/S2215-0366(15)00321-1

Nikolas MA, Elmore AL, Franzen L, O'Neal E, Kearney JK, Plumert JM. 2016. Risky bicycling behavior among youth with and without attention-deficit hyperactivity disorder. J Child Psychol Psychiatry. 57(2):141–148. doi: 10.1111/jcpp.12491

Roudsari BS, Shadman M, Ghodsi M. 2006. Childhood trauma fatality and resource allocation in injury control programs in a developing country. BMC Public Health. 6:117. doi: 10.1186/1471-2458-6-117

Ruiz-Goikoetxea M, Cortese S, Aznarez-Sanado M, Magallón S, Alvarez Zallo N, Luis EO, de Castro-Manglano P, Soutullo C, Arrondo G. 2018. Risk of unintentional injuries in children and adolescents with ADHD and the impact of ADHD medications: a systematic review and meta-analysis. Neurosci Biobehav Rev. 84:63–71. doi: 10.1016/j.neubiorev.2017.11.007

Sandels S. 1970. Young children in traffic. Br J Educ Psychol. 40(2): 111–116. doi: 10.1111/j.2044-8279.1970.tb02111.x

Sandford JA, Turner A. 1995. Manual for the integrated visual and auditory continuous performance test. Richmond, VA: Braintrain.

Schwebel DC, Gaines J, Severson J. 2008. Validation of virtual reality as a tool to understand and prevent child pedestrian injury. Accid Anal Prev. 40(4):1394–1400. doi: 10.1016/j.aap.2008.03.005

Schwebel DC, Severson J, He Y. 2017. Using smartphone technology to deliver a virtual pedestrian environment: usability and validation. Virtual Real. 21(3):145–152. doi: 10.1007/s10055-016-0304-x

Stavrinos D, Biasini FJ, Fine PR, Hodgens JB, Khatri S, Mrug S, Schwebel DC. 2011. Mediating factors associated with pedestrian injury in children with attention-deficit/hyperactivity disorder. Pediatrics. 128(2):296–302. doi: 10.1542/peds.2010-3829

Tabibi Z, Pfeffer K. 2003. Choosing a safe place to cross the road: the relationship between attention and identification of safe and dangerous road-crossing sites. Child Care Health Dev. 29(4):237–244. doi: 10.1046/j.1365-2214.2003.00336.x

Tabibi Z, Pfeffer K. 2007. Finding a safe place to cross the road: the effect of distractors and the role of attention in children's identification of safe and dangerous road-crossing sites. Infant and Child Dev. 16(2):193–206. doi: 10.1002/icd.509

Tabibi Z, Pfeffer K, Sharif JT. 2012. The influence of demographic factors, processing speed and short-term memory on Iranian children's pedestrian skills. Accid Anal Prev. 47:87–93. doi: 10.1016/j.aap.2012.01.013

Tabibi Z, Schwebel DC, Zolfaghari H. 2022. Road-crossing behavior in complex traffic situations: a comparison of children with and without ADHD. Child Psychiatry Hum Dev. 53(6):1186–1193. doi: 10.1007/s10578-021-01200-y

Tai YM, Gau SS, Gau CS. 2013. Injury-proneness of youth with attention-deficit hyperactivity disorder: a national clinical data analysis in Taiwan. Res Dev Disabil. 34(3):1100–1108. doi: 10.1016/j.ridd.2012.11.027

van der Molen HH. 1981. Child pedestrian's exposure, accidents and behavior. Accid Anal Prev. 13(3):193–224. doi: 10.1016/0001-4575(81)90005-1

Vinje MP. 1981. Children as pedestrians: abilities and limitations. Accid Anal Prev. 13(3):225–240. doi: 10.1016/0001-4575(81)90006-3

Wamithi S, Ochieng R, Njenga F, Akech S, Macharia WM. 2015. Cross-sectional survey on prevalence of attention deficit hyperactivity disorder symptoms at a tertiary care health facility in Nairobi. Child Adolesc Psychiatry Ment Health. 9(1):1. doi: 10.1186/s13034-015-0033-z

Whitebread D, Neilson K. 2000. The contribution of visual search strategies to the development of pedestrian skills by 4-11 year-old children. Br J Educ Psychol. 70(4):539–557. doi: 10.1348/000709900158290

Willcutt EG, Doyle AE, Nigg JT, Faraone SV, Pennington BF. 2005. Validity of the executive function theory of attention-deficit/hyperactivity disorder: a meta-analytic review. Biol Psychiatry. 57(11): 1336–1346. doi: 10.1016/j.biopsych.2005.02.006