

Impact of Attention Deficit Hyperactivity Disorder (ADHD) of Licensed Motorcycle Riders on the Occurrence of Road Accidents in Israel

Running Head: Motorcycle Road Accidents Involving Licensed Operators with ADHD

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Abstract:

Background: Multiple analyses have been performed in search for reasons for vehicular accidents. While those that involve motorcycles account for a large proportion of traffic accidents worldwide, most investigations regarded car accidents. Attention deficit hyperactivity disorder (ADHD) affects 7-10% of children worldwide and is ever a continuously growing syndrome. More than 70% of these will suffer from it as adults. There are no data on the numbers of motorcyclists who had been diagnosed as having ADHD and what is the magnitude of the association between ADHD and motorcycle accidents. This report aims to explore the extent of such an association.

Methods: The database of a pain clinic was retrospectively searched for all cyclists diagnosed as having ADHD who presented with pain following motorcycle accidents between 2014-2021.

Results: Out of a cohort of 1162 persons, 178 individuals underwent motor vehicle accidents (MVA), of whom 136 (76.4%) had been diagnosed with ADHD either during childhood or later on. Among car drivers, approximately 37% of the injured suffered from ADHD. The mean age of all motorcyclists was 34 years, and it included 164 males vs. only 14 females. They all denied having been intoxicated by any substance at the time of the accident. Six only were using a stimulant (methylphenidate, Ritalin® (occasionally).

Conclusions: Our finding of the presence of ADHD in over three-quarters of cyclists who sought relief of chronic pain following a non-fatal motorcycle accident is overwhelming and therefore should be considered a cause for limiting licensing to operate a motorcycle to some or implementing periodical medical examinations among such individuals.

Keywords: attention deficit hyperactivity disorder; motorcycle road accidents

Introduction

Road traffic accidents are a leading cause of death and injuries worldwide (1-4). Cost of fatal and nonfatal crashes has been estimated as a yearly tax of 0.12% on global GDP (gross domestic product) (5). Although motorcycles comprise only ~3% of all registered vehicles and 0.6% of all vehicle miles traveled in the US, motorcyclists reportedly accounted for 14% of all traffic fatalities, 18% of all occupant fatalities, and 4% of all occupant injuries in

2020 (6). Whereas the number of nonfatal injuries in the US decreased by ~2% from 2020 to 2021, the injury rate increased by 10% from 2019 to 2020 as reported by the National Highway Traffic Safety Administration (NHTSA) (7). In Israel, approximately 10% of the fatalities sustained from motor vehicle accidents (MVA) involve motorcyclists (4), while motorcycles represent only 4% of all motor vehicles on the road, similar to the percentage in the US (8). The numbers of large motorcycles has recently increased in Israel as it has worldwide, due to the relatively lower prices compared to a decade ago. In fact, the number of two-wheeled vehicles has increased by approximately 50% in Israel during the past decade (4).

The prevalence of ADHD in the general Israeli population has been estimated as being 5-10% (9) compared to 13% males and 4.2 % females worldwide (10). Sadeghi-Bazargani et al. correlated ADHD with road mishaps in general (11), but those authors did not estimate the magnitude and the relationship between motorcycle accidents and cyclists with ADHD. The current data was extracted from the medical records of patients who sought relief from chronic pain resulting from a motorcycle accident which they were operating. Our report is one step further, aiming to elucidate these and other reports (12), depicting the *magnitude* of the incidences of non-fatal accidents among motorcyclists suffering from ADHD.

Methods

Motorcycle Operator License Requirements in Israel

Motorcycle licensing in Israel requires age above 16 years following a comprehensive medical exam. A motorcycle <125 cc is licensable to individuals from 16 years of age with parental consent, one up to 47.46 HP to individuals older than 18 years, and heavier motorcycles to individuals from 21 years. The applicant of a legal license must pass a written examination as well as a road test.

Study Participants

Data for the current study were retrieved from the database of a pain clinic during the 8-year period, from January 1, 2014 to December 31, 2021 of individual who sought relief from chronic pain. This report later selectively analyzed data associated with motorcyclists involved in a road accident. Demographic information (age, sex), past and current medical history, and a description of the pain sustained at the time of presentation to the clinic, were recorded. The individuals who had been diagnosed as having ADHD were identified and selected for further study.

Statistical analyses were performed by a qualified academic statistician. Categorical variables were summarized using absolute and relative frequencies or percentages based upon non-missing cases. The two-sample t-test or the Wilcoxon rank sum test were used as appropriate for comparisons of means (continuous variables). The Chi-squared test or the Fisher's exact test were used as appropriate for comparison of proportions (categorical variables). Hommel's test was used to address multiple testing issues. The patients' self-rated pain (originally based on a 1-10 numerical rating scale, then transformed into a three-grade scale of pain for better clarity, see Table 1) at arrival to the clinic were

compared by ANOVA with repeated measures, and the ANOVA tests were followed by an appropriate *post-hoc* test.

The level of significance for all tests was set to 0.05. All statistical analyses and data presentations, including tabulations and listings, were performed using the SAS® software (Enterprise Guide 7.1 SAS Institute, Cary NC, USA).

Ethics Statement

This report has obtained the acknowledgement of the Tel Aviv Sourasky Medical Center's Helsinki Committee to present and report the data originating from a public out-of-hospital pain clinic. All patients gave an informed consent to use their data anonymously for publication

Results

A total of 1162 individuals visited the pain clinic during the 8-year study period. The demographic characteristics are listed in Table 1. The majority of the presenting complaints involved physical pain, with very little mention of psychological disturbances (data not shown). One-third of the cohort attributed their chronic pain to road accidents (Table 2), all but 5 took place within urban areas, driving for pleasure or during working time; the vast majority of this population was males (Table 2). Noteworthy, all of the individuals were in possession of a license to operate the vehicle in question.

While all of the victims of various types of MVAs reported that they had previously enjoyed good health, 136 of the 178 who had motorcycle accidents (76%) stated that they had been diagnosed with past or current ADHD; six individuals used sporadically medical stimulant (methylphenidate, Ritalin). The proportion of motorcycle operators with ADHD was significantly higher than that of the 144 individuals who underwent car accidents among whom 28.5% reported having been diagnosed as having ADHD ($P<0.00001$). Interestingly, the number of female ADHD motorcyclists was only one-third of the female car drivers involved in accidents, while motorcyclist ADHD males accounted for 50% more than ADHDs car drivers ($P<0.005$).

The ADHD motorcyclists were significantly ($P=0.0027$) younger than the non-ADHD motorcyclists, while the mean age of the ADHD drivers involved in car accidents was lower but not significantly different from the motorcyclists counterparts' mean age ($P=0.2277$). However, the motorists with ADHD were significantly younger than the rest of the entire study cohort ($P=0.0001$) (Table 3). Comparably, the mean age of the non-ADHD motorcyclists was similar to that of the non-ADHD car drivers, but both sub-groups' ages were much younger than the rest of the cohort ($P=0.0001$). (Table 3).

As for disability, which is one of the major post-accident's consequences (pain excluded), more motorcyclists had various degrees of disabilities in terms of being unable to return to work as determined by the Israeli National Security Insurance Organization, as compared to those involved in car accidents (Table 3). At the same time, more ADHD individuals were certified disabled for work after motorcycle accidents than those who had

not been diagnosed with ADHD. Proportionately, the number of those who were disable to work after motorcycle accident, be they ADHDs or non-ADHDs, was only slightly lower than those for both the ADHD and non-ADHD car operators, as well as when compared to the rest of the cohort ($P=NS$, Table 3).

Parameter	Males	Females	Entire cohort	P value	P value a
Gender	66.1%, n=768	33.9%, n=394	n=1162	<0.001	<0.001
Age (years)	42.8 ± 16.6	52.8 ± 18.8	46.2 ± 18	<0.001 f	<0.001
Pain quotation ^b	1.52 (mean) 1.0 (Median)	1.50(mean) 1.0 (Median)	1.52(mean) 1.0 (Median)	0.8632 d	0.8632
Patients unable to return to previous work (% , n)	38.6, 296/766	36.5, 144/394	37.9, 440/1160	0.4863 ^e	0.7644
Patients able to perform daily/home tasks (% , n)	60.6, 464/765	50, 196/392	57, 660/1157	0.0005 ^e	0.0111
Officially declared <50% disability ^c (% , n)	50, 148/296	47.2, 68/144	49.1, 216/440	0.5845 ^e	0.7644
Officially declared >50% disability ^c (% , n)	50, 148/296	52.8, 76/144	50.9, 224/440	0.5845 ^e	0.7644

Table 1 Demographic and administrative data.

Values are expressed as mean ± SD, percent, or number of cases.

^a Multiple comparison

^b See text for pain current classification

^c As defined by the Israeli National security Insurance; see text

^d Mann Whitney U Test

^e Chi square

^f T Test

Parameters	Males	Females	All individuals	P value a	P value b
MVA – car (% , n)	13.4%(103/768)	10.4%(41/394)	12.4(144/1162)	0.1411	0.7644
MVA – motorcycle (% ,n)	21.4%(164/768)	3.6%(14/394)	15.3%(178/1162)	<0.0001	<0.0001
MVA – pedestrian (% , n)	3.4%(28/768)	3.1%(12/394)	3.4(40/1162)	0.7579	0.7644
ADHD [involved in MVAs] (% , n)	38.7%(297/768)	12.7%(50/394)	29.9%(347/1162)	<0.0001	<0.0001

Table 2. MVAs' stratification of the cohorts.

MVA – motor vehicle accidents.

^a Chi-square test

^b Multiple comparisons

Parameters	MVA – cars	MVA - motorcycle	Rest of cohort
Individuals w/ ADHD (% , n)	38 (50/132) ^a	76.4 (136/178)	20 (161/802)
Individuals w/o ADHD (% , n)	7 (142/182) ^a	23.1 (42/178)	80 (641/802)
Age individuals w/ ADHD	35.9 ± 9.5 ^e	33.7 ± 10.4	39.6± 13.6 ^e
Age individuals w/o ADHD	44.3 ± 15.5	40.1 ± 15.9	51.7± 18.9
Work-related disability of <50% / >50% of individuals w/ ADHD (n, %)	8/8 Out of 50; 32%	29/20 Out of 136; 34%	32/39 Out of 211; 34%
Work-related disability of <50% / >50% of individuals w/o ADHD (n, %)	23/17 Out of 142; 28%	9/8 Out of 42;40%	113/132 Out of 773; 32%

Table 3. Characteristics of post-accident victims with and without ADHD vs the rest of the cohort.

Values are expressed as mean ± SD, percent, or number of cases.

^a Including pedestrians ^b Multiple comparisons ^c Chi-square test

^d ANOVA w/ repeated measures

^e P< 0.001 by ANOVA vs. the non-ADHD counterparts

Discussion

MVAs can be the consequence of a variety of driver impairments that are essentially associated with distractions. Earlier reports have concentrated on MVAs in general, and mostly dealt with cars. The findings of this report establish ADHD as a major cause for their occurrence and that its frequency among motorcycle operators is disproportionately high. It emerged that cycle operators with ADHD comprise up to 76% of the subjects who were involved in non-fatal accidents compared to <30% of non-ADHD operators who approached the pain clinic. One-third of the motorcyclists involved in accidents were females compared to 10% of female drivers of cars involved in accidents. In addition, the motorcyclists with ADHDs were much younger than any group in the entire study cohort.

Most of the studies that had demonstrated that ADHD plays a role in vehicular crashes or near-crashes, were observational and mainly discussed behavioral aspects of car operators with ADHD (13), also comparing data obtained experimentally from drivers with to those without ADHD (12,14,15). Also, the presence of ADHD and driving behavior scores were shown to affect the likelihood of motorcycle traffic injuries among motorcycle operators independently of other pre-injury indicators, including education, purpose of riding, and economic status (11,16).

While our findings support these results, we rather demonstrate, hazards even in the absence of an imminent crash has not been fully illustrated. While the effect of *external* distractions, such as billboards, have been given much attention (mostly for drivers of vehicles other than motorcycles), relevant *internally-associated* distractions that affect ADHD-related behavior were practically suggestive (18-22).

In a study on post-MVA after adjustment for a range of potential confounders (12), the authors suggested that drivers with ADHD who are exposed to both external and internal distractions are significantly more likely to be responsible for an MVA. If impaired, the cognitive system that provides temporary storage and manipulation of the information necessary for complex cognitive tasks fails to operate (23). Working memory impairments may thus be the responsible factor for difficulties in completing two tasks simultaneously (dual tasking) or resisting an external distraction. External distractions may compete with the main task of driving and involve the driver in a dual tasking situation which overloads his performance through a large range of inattention-related impairments, among them failing to detect stimuli in the periphery of the visual field, fewer rear-view mirror checks, and increasing time to reaction (24). The more the secondary task calls upon cognitive processing resources, the more it alters the driver's behavior in terms of being distracted by secondary information (i.e., indicating a situation of danger), to quickly process that information, and to quickly return to the main task of safe and attentive driving. This momentary distraction can lead to a crash or near-crash event. Thus, because of a higher susceptibility to being distracted by surrounding stimuli, the same external distraction can more easily capture the attention of a driver with ADHD and cause greater attention failures than that of a non-ADHD driver, resulting in a greater risk of being responsible for an accident.

Importantly, very few individuals are on anti-ADHD medications (12), as emerges in the present report. Therefore, registered individuals with ADHD are actually under detected (25), which is another reason to believe both that experimental data are likely unreliable, and that our data are reliable and represents reality in practice.

Medications may have a role in reducing MVAs among motorists of all kinds. This is a debated issue, since it has been argued that

ADHD-specific medications may not predict ADHD-related driving behavior improvement, and that adverse effects from ADHD pharmacotherapies may rather interfere with driving (26). The use of medications could produce significant reduction of the described catastrophe, however like during the COVID pandemic' loud objective voices would block such an initiative. It is also doubtful whether it is possible to regulate and control the impulsive behavior reflected in speeding, frustration with other road users, less safety when changing lanes on the motorway, and a greater likelihood of an accident following an unexpected event — all more intense in individual with ADHD while driving, even those who are treated (27). Contrarily, when evaluating the association between psychiatric diagnoses, motorcycle accidents, and traffic violation tickets among 101 adolescent motorcyclists under laboratory conditions, the prevalence of mental disorders was much higher in that study sample than in the general population (28). Those findings join our urgent call to public mental health planners and transportation authorities to intervene with both preventive and treatment measures, aiming at improving driving behavior and increasing road safety. Finally, 35 ADHD adolescents (19 boys and 16 girls, mean age 17.8 years) were compared in a randomized, double-blind, placebo- controlled, crossover study design, and time-related (evening vs. night) on a laboratory driving simulator after taking 72 mg of an osmotic-release oral system (OROS) methylphenidate, 30 mg of mixed amphetamine salts extended release, or placebo. Compared to placebo, OROS methylphenidate resulted in less time driving off the road, fewer instances of speeding, less erratic speed control, more time executing left turns, and less inappropriate use of brakes. OROS methylphenidate and mixed amphetamine salts extended release worked equally well for male and female adolescents as well for teenagers with combined and inattentive subtypes of ADHD. Those authors concluded that stimulants improve driving performance in ADHD adolescents based on laboratory findings of OROS methylphenidate (29).

The results of the current study should motivate transportation authorities, physiologists, psychologists, and psychiatrists to further investigate the strong link between ADHD and MVAs. We recommend that large random controlled trials be conducted in order to better compare real- life occurrences on the road between motorcyclists with ADHD and those without. A possible use of ADHD pharmacological agents (i.e., methylphenidate, lisdexamfetamine, dexamphetamine, atomoxetine, guanfacine) in ADHD individuals could be a starting point for the prevention of ADHD-related abnormal behavior on the road and loss of lives, similar to epileptic drivers who use medications when driving (29,30). It might also be prudent to limit of the use of high-volume engine motorcycles among severe ADHD individuals or among those with any degree of ADHD who refuse recommended treatments. Also, enforcing a preventive and safety program for motorcyclists, including awareness to use the correct lane, and introducing a campaign to educate the public about the risk of the failure to yield via social media, should be encouraged. No effort should be spared given that motorcycle accidents are a source of ever-increasing road traffic deaths and injuries. Indeed, they are the number one cause of death among young adults in North America and will probably become the fifth leading cause of death by 2030 if preventive interventions are not implemented quickly (World

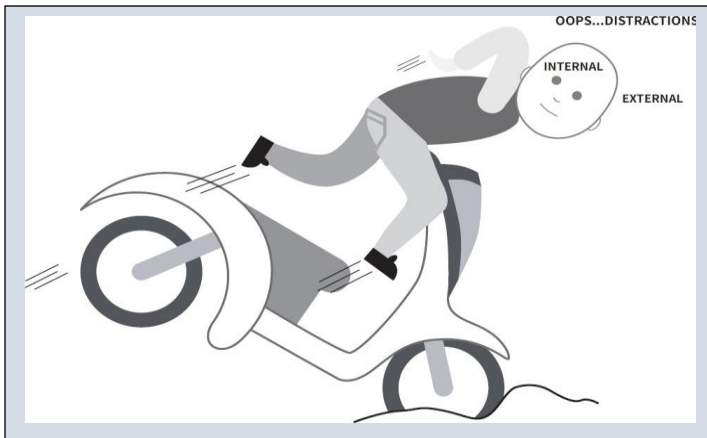
Health Organization).

In opposition to the above recommendation, Lidestam et al (31) found that drivers with ADHD and non-ADHD controls drive remarkably similarly when tested in simulator driving tests (SDT), suggesting that drivers with ADHD are less deviant than indicated by previous research. Those authors concluded that neuropsychological maturation and driving experience may decrease the adverse effects of ADHD rather than medications. Similarly, to Selander et al (32,33), we believe that it is likely that many of those laboratory-tested individuals with severe neuropsychiatric symptoms never manage to obtain a driving license in the first place and would therefore never cause actual MVAs. It should be borne in mind that simulation only resembles real-life road driving capabilities of ADHD and non-ADHD individuals; therefore, the data of the present study reflect relevant, real-life and specific ADHD-related motorcyclists' experiences.

The injuries sustained as a result of motorcycle accidents mostly impacted the body skeleton, (more spines than limbs), almost none requiring surgery. This finding indicates a low-to-medium range of the vector forces that the individuals were subjected to, during collisions in urban areas. Among all motorcyclists, a very limited number of patients (3) sustained internal injuries, while there was only one case of concussion among all our cases. Importantly, no illegal speeding violations, issuance of fines, driving while exhausted or under drug or alcohol influence, or talking with passengers, as well as proven maneuvering while driving any motor vehicle as well as motorcycles, were reported, which could have affected any (including ADHD) motorcyclist, when involved in a road accident, as compared to a previous study (34). Importantly, none was involved in food and general marketing delivery system.

The youngest recorded age of our participants was 18 years. While the age ranges of the overall MVA victims were similar to those of earlier reports (35), there was a significant difference between the mean age of the ADHD motorcyclists and that of the car drivers, in line with earlier descriptions of a significant association between risky riding behaviors and the driver age (16,36). Indeed, according to data from the Israeli Motor Division, 1 out of every 173 19-year-olds licensed to operate motorcycles is seriously injured or killed. That rate is higher than the five motorcyclists in the 35-44 years age group. Those figures mean that the risk for a young motorcyclist in Israel is more than 10 times higher compared to a middle-aged one (4). Our report thus supports the dominant role of ADHD on behavior in this age range as well. Finally, the figures showing a lower distribution rate of females among motorcyclists compared to drivers of cars has never been reported previously. This is probably associated with the fact that in 2018, the estimated number of motorcycles owned by females, and passengers of any motorcycle registered by a woman, was 19 percent. This relatively lower rate of females riding motorcycles compared to their car driving population (4,37) is well reflected by our data.

Graphic Illustration



Limitations

This report has some limitations that bear mention. First, it does not include individuals with ADHD who were involved in accidents and who later either recovered without residual pain or who did not seek relief from pain in the setting of a pain clinic. It is also true with regard to those who underwent fatal MVAs. Second, no specific levels of ADHD were herein provided since none were recorded for the individuals who presented to the pain clinic. Such specific testing was introduced in Israel only very recently. Related to that is the possibility that there were subjects who were aware of having been diagnosed as having ADHD and were reluctant to divulge that information, whereupon the number of participants with ADHD would be an underestimation. In addition, several dissimilar physio-neuro-pathological models and scales have been suggested in order to explain diverse behavioral distraction on the road by individuals with ADHD (38,39), which could explain dissimilar laboratory experimental results of ADHD-associated behavioral attitudes overall. Indeed, there are only very few in-depth investigations on psycho-neuro-manual attributes proven to characterize critical driving tasks based on signals and scores among ADHDs (11,40). Such lack of homogeneity trims down the denotation of the lack of our patients' ADHD scoring.

Finally, the weight of the motorcycle and the volume of its engine are additional factors that were considered by others with regard to MVAs, but not mentioned in the current report, since there is no reference in Israeli records as to the weight or engine power of the motorcycle involved in accidents, nor is there any information with regard to the type of the collision (side swipe, head-on crash, etc.).

In summary, ADHD is a complex neurodevelopmental and psychological disorder, associated with cognitive behavior that affect individuals' daily activities. Factors that are to be blamed for occurrence of road accidents among all road users, such as risky or illegal driving behaviors, inattention, dysregulation of waking systems, usage of social networking sites while driving, substance abuse, and/or aggressiveness – all could be more frequent among ADHDs. The current report provides, for what we believe to be the first time, the extent of ADHD involvement in motorcycle accidents among operators who sought pain relief following an accident. This report calls for revisiting the qualifications of a

motorcycle license applicant and to incorporate evaluations of fitness to operate the vehicle in the presence of ADHD at determined time intervals. This requires across-the-board joint action made by medical and transportation authorities for the benefit of all road users.

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