

Prevalence of Central Nervous System Diseases – A Large Retrospective Cohort Study of Adolescents

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Key words

- adolescents
- nervous system
- prevalence
- epidemiology

Abstract

At age sixteen, most Israeli nationals must undergo medical evaluation for compulsory military duty. All potential conscripts are referred to the Israel Defense Forces (IDF) recruiting office. Therefore, medical screening of a vast number of adolescents is performed, offering a unique opportunity to study the prevalence of neurological diseases in an entire age cohort. Hence, screening is not affected by diagnostic or methodological bias. We performed a retrospective neuroepidemiological large cohort study of adolescents from the database of the Israel Defense Forces recruiting office during the years 1998–2002. The survey included 409 492 adolescents, among them 162 079 (39.5%) females. The

most prevalent diagnoses were: headache (754 per 10 000 adolescents), permanent brain damage (197 per 10 000), epilepsy (167 per 10 000) and movement and coordination disorders (36 per 10 000). These were followed by cranial nerve disorders, sleep disorders, cranio-spinal bone defects, and chronic progressive CNS disorders. The relative risk for male adolescents within the specific disease groups was higher for movement-coordination, sleep and cranial nerve disorders. Multivariate analysis revealed gender and severity prevalence and sex-grade, or year-grade interactions in the distinct groups of diseases. This study provides important information on the prevalence of neurological diseases in adolescents and demonstrates some significant epidemiological trends.

Introduction

Although neurological diseases are rarely the direct cause of death, they account for a large proportion of disability in the population and impose an economical burden on society [10, 19, 21, 28]. An analysis of expenditure in England for the years 1992–1993 showed that nervous system diseases accounted for 8.4% of the total health and social services costs [19]. The World Health Organization assumes that by 2020, stroke will account for 6.2% of the total burden of illness while dementia and other degenerative central nervous system diseases will affect another 3.5% of the population [21]. Population-based epidemiological studies of nervous system diseases are usually performed on representative samples, often leading to some inaccuracies. At the age of sixteen, all Israeli Jewish citizens become candidates for mandatory military service and are obliged by law to attend the Israel Defense recruiting office. Medical screening of

adolescents for the universal military service in the Israeli Defense Forces (IDF) thus offers a unique opportunity for studying the prevalence of neurological diseases in a large cohort of adolescents. Since a large cohort is examined in the same manner, the results might not be influenced by potential diagnostic or methodological bias. The health status of teenagers not only reflects the cumulative incidence of diseases throughout childhood, but also helps to predict the health status of adults and to estimate its impact on health services. While many studies have reported the prevalence of distinct neurological diseases in adolescents, such as headache and epilepsy, large epidemiological surveys about the frequency of all neurological diseases in this age group have not been published. This study is unique in its being based on national data, which include valid measurements for almost the entire populations, conducted by physicians. Therefore, this study provides important information on the prevalence of neurological

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Table 1 Severity grading of the four most prevalent neurological disorders.

Grade of severity	Headache	Movement and coordination disorders	Permanent brain damage	Epilepsy
I	mild (0–1 attacks per month during the last year)	mild	history of CNS injury with subjective complaints but no objective neurological findings	last attack more than 5 years, no treatment
II	moderate (1–4 attacks per month during the last year)	moderate	CNS injury with mild to moderate neurological dysfunction	last attack more than 5 year with treatment or last attack less than 5 years, treatment yes/no
III	severe migraine (more than 4 attacks per month or a documented neurological deficit)	severe	CNS injury with severe neurological dysfunction	last attack less than 1 year, treatment yes/no
IV				uncontrolled epilepsy

diseases in adolescents and demonstrates some significant epidemiological trends.

Patients and Methods

All Jewish-Israeli nationals undergo medical pre-recruiting evaluation at the age of sixteen. This does not include Israelis of Arab origin or religious Ultra-Orthodox Jews, who are exempted from military service by law. This extensive evaluation involves medical and socio-demographic profiling. The acquired information is stored in a computerized database. This screening also includes individuals with chronic conditions who may not be eventually recruited.

The medical examinations are performed by general practitioners at the recruiting office. Medical history and demographic characteristics are obtained using a pre-examination comprehensive questionnaire, a review of the patient's primary physician's chart, and a detailed interview of the candidate. Conscripts with a known neurological disorder or those reporting neurological symptoms are referred for neurology consult. Additional tests are performed, if indicated, to establish a final diagnosis. Candidates hospitalized in chronic hospitals were screened by documented medical records and did not have to appear at the recruiting office.

In the military health system, neurological diseases are categorized into the following groups based on explicit diagnostic criteria.

Cranial nerve disorders. This group includes lesions of one or more cranial nerves. The severity of the lesion is established according to the functional disability caused by the lesion and graded as mild, moderate or severe.

Headaches. This group includes migraine and its subtypes, tension, exertional, and cluster headache, trigeminal and post-herpetic neuralgia, pseudotumor cerebri and post-traumatic headache. Severity of headaches is graded from I–IV as indicated in [Table 1](#).

Epilepsy. This group comprises generalized and focal epilepsies as well as epilepsy syndromes. Disease severity is classified into four categories, according to seizure frequency and/or treatment and independently on epilepsy type or syndrome ([Table 1](#)).

Permanent brain damage. The diseases in this group involve a broad spectrum of central nervous system lesions with an acute onset and non-progressive course, i.e., sequelae of meningoen- cephalitis, head trauma, congenital and developmental nervous system diseases including, among others, hydrocephalus,

cerebral palsy, chromosomal abnormalities, phakomatoses etc. The severity of the condition is graded from I–III ([Table 1](#)).

Movement and coordination disorders. This includes a large group of neurological diseases that manifest mainly by movement and coordination difficulties such as dystonia, hereditary and paroxysmal ataxia, essential tremor, and other extra pyramidal syndromes. Simple tics, multiple tics, habit spasms and Tourette syndrome are also grouped under this heading. In this group we also include attention deficit hyperactivity disorder. The severity of disability is graded I–III ([Table 1](#)).

Chronic progressive disorders of the CNS. In this group are included all diseases that cause a non-reversible, or partially reversible damage of the brain and spinal cord and have a possibly progressive course such as vascular disorders, demyelinating diseases, inherited and acquired metabolic disorders of the CNS etc.

Sleep disorders. This includes primary and secondary insomnia, hypersomnia, sleep apnea, narcolepsy and catalepsy, parasomnias, and delayed-sleep-phase syndrome.

Cranio-spinal bone defects. This refers to defects of the skull bone and craniospinal deformities. The disability grade in this group is judged according to the extent of the defect or the functional restriction caused by the abnormality and graded as mild, moderate and severe.

We performed a retrospective neuroepidemiological study from the database of the Israel Defense Forces recruiting office.

Statistical methods

We investigated a possible effect and interrelation of gender, disease severity and year of screening in each of the neurological diseases categories. The percentage of adolescents within the distinct groups of disorders was analyzed by a three-way ANOVA (multivariate ANOVA), using the factors “year” × “gender” × “grade” with two-way interactions. The Tukey's procedure for pairwise comparison was applied for the post-hoc analysis. The statistical power (p) was considered significant if less than 0.05.

Results

The survey included 409492 adolescents, among them 162079 (39.5%) females. The results are shown in [Table 2](#). The prevalence of neurological disorders is depicted in [Table 3](#) and [Fig. 1](#). The most prevalent diagnoses were headache, permanent brain damage, epilepsy and movement and coordination disorders. These were followed by cranial nerve disorders,

Table 2 Results of screening according to sex, year and grade.

Year	1998		1999		2000		2001		2002	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
headache										
I	1200	799	1318	875	1164	788	921	641	1184	666
II	184	304	279	438	300	380	247	356	317	466
III	115	166	153	253	191	246	286	313	422	389
permanent CNS damage										
I	85	339	107	422	88	363	72	247	111	377
II	29	57	25	63	16	58	20	39	17	57
III	90	185	125	256	109	217	102	187	139	289
epilepsy										
I	60	97	83	147	43	123	64	108	54	109
II	24	39	31	40	29	35	35	43	20	40
III	81	139	92	167	72	100	69	88	87	169
IV	47	131	72	179	68	152	86	134	130	195
cranial nerve injury										
mild	21	41	27	33	28	28	26	39	39	25
moderate	6	4	4	8	6	9	3	4	5	9
severe	1	2	0	7	1	2	0	3	1	4
movement and coordination disorders										
I	9	96	20	124	18	135	20	124	15	164
II	3	10	2	17	0	9	1	14	3	28
III	2	2	0	6	0	4	0	6	2	14
sleep disturbances										
mild	3	11	0	7	1	20	1	7	2	11
moderate	3	49	8	53	8	57	10	52	19	63
severe	1	4	1	5	0	1	0	3	0	4
cranio-spinal bone defects										
mild	6	23	16	27	10	27	13	23	15	23
moderate	0	3	0	1	1	1	0	1	0	5
severe	0	1	1	1	0	0	0	0	0	2
chronic progressive CNS disorders										
	5	20	7	13	15	25	11	12	22	25

Table 3 Prevalence of neurological disorders.

		No. of cases per 10 000	CI (95%)	Relative risk
headache	male	367.73	(360.32, 375.14)	0.95
	female	386.42	(377.03, 395.80)	
permanent CNS damage	male	127.56	(123.14, 131.98)	1.82
	female	70.03	(65.97, 74.09)	
epilepsy	male	90.33	(86.61, 94.06)	1.17
	female	76.94	(72.68, 81.19)	
movement and coordination disorders	male	30.43	(28.26, 32.61)	5.19
	female	5.86	(4.68, 7.04)	
cranial nerve disorders	male	39.25	(36.78, 41.71)	3.78
	female	10.37	(8.80, 11.93)	
sleep disturbances	male	14.03	(12.55, 15.50)	3.98
	female	3.52	(2.60, 4.43)	
cranio-spinal bone defects	male	5.58	(4.65, 6.51)	1.46
	female	3.83	(2.87, 4.78)	
chronic progressive CNS disorders	male	3.84	(3.07, 4.61)	1.04
	female	3.70	(2.77, 4.64)	

sleep disorders, cranio-spinal bone defects and chronic progressive CNS diseases.

Males showed an increased risk for movement-coordination disorders, sleep and cranial nerve disorders (► **Table 3**). Multivariate analysis showed that within the group of headache, males suffered more frequently than females ($p < 0.001$). Mild headaches were more frequent than moderate and severe headaches

($p < 0.001$). An interaction between gender and headache severity was found ($p < 0.001$), showing that males had a tendency to suffer from mild headaches, while gender distribution was similar for moderate and severe headaches with a slight female preponderance. Headache severity was comparable in each of the five years except for 2001 when the number of adolescents with

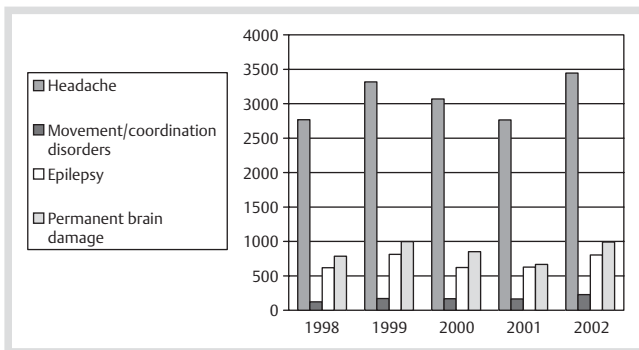


Fig. 1 Number of adolescents with the four most prevalent neurological diseases during each year of the survey.

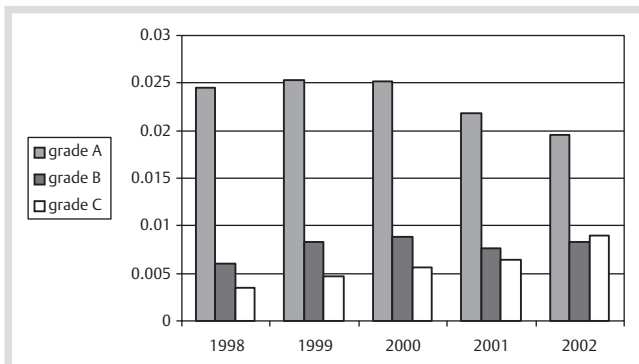


Fig. 2 Number of adolescents with headache (in percentages) according to year and severity.

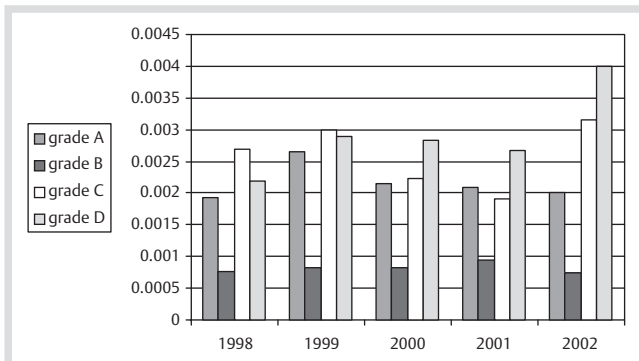


Fig. 3 Number of adolescents with epilepsy (in percentages) according to year and severity.

mild headaches decreased and those with severe headaches increased ($p=0.02$) (● Fig. 2).

Among adolescents with permanent brain damage, males were overrepresented ($p<0.001$). Mild brain damage was diagnosed most frequently, followed by severe and moderate brain damage ($p<0.001$). Between 1998 and 1999 and 2001 and 2002, a significant raise in cases of permanent brain damage was found, while between 2000 and 2001 a decrease was noted ($p=0.03$). An interaction between gender and severity of the disease was found, showing that males had more mild and severe permanent brain damage than females ($p<0.001$) whereas no sex differences were observed in the subgroup of moderate permanent brain damage.

Epilepsy was more common in males than females ($p<0.001$), mostly for more severe grades of the disease (grades III and IV, $p<0.001$). An increase in the number of epileptic patients was

registered in 2002 as compared to the previous years ($p<0.001$), especially for the more severe grades of the disease ($p=0.018$) (● Fig. 3).

Males were also more frequently affected by movement and coordination disorders ($p<0.001$). Mild forms of the diseases were most common, followed by moderate- and severe forms ($p<0.001$). No interaction was found between disease severity and gender or calendar year. For cranial nerve disorders the mild form predominated ($p<0.001$) and no sex preference was found.

More male adolescents complained of sleep disturbances ($p<0.001$), mostly for cases of moderate severity which was also the most frequent form ($p<0.001$). A significant increase in sleep disturbances was noted between the years 2001 and 2002 ($p=0.027$).

Cranio-spinal bone defects occurred more frequently in a mild form ($p<0.001$) and in men ($p<0.001$), whereas no gender differences were found for the moderate and severe forms of the defect.

Chronic progressive diseases had a similar prevalence in each year of the study. Males demonstrated a slight tendency to be more affected than females ($p=0.051$). No grading for this heterogeneous group of disorders was available.

Discussion

The classification of the central nervous system disorders in this study was created for military purposes and was made for practical rather than diagnostic intentions. For example, central nervous lesions are divided in non-progressive (permanent brain damage) and those with a variable and possibly progressive (progressive brain diseases). Movement/coordination disorders constitute a special interest group, as the main symptoms affect the dexterity of the affected individual. Headaches, as well as epilepsy constitute separate classification groups in view of the unpredictability and potential functional impact on the conscript. Furthermore, sleep disorders, too, are an outstanding group due to the implications of parasomnias on weapon holding or the possible implication of insomnias on guarding and driving.

Nonetheless this study, performed during a period of five years, included practically the whole cohort of secular Jewish late adolescence population. We found that headaches, movement/coordination disorders, epilepsy and sequelae of previous brain damage are common among Israeli adolescents.

Headaches were the most prevalent condition among Israeli adolescents (7.6%). In previously reported epidemiological studies, headache prevalence in adolescents ranged between 6 and 69% [2,4,6,9,10,14,15,24,27,29]. However, published studies varied in the number of screened individuals (hundreds to thousands), the time-frame of the screened periods (months to years to lifetime), and the classification of the headaches (tension, migraine or cluster headaches). In general, females are reported to suffer more often from headache than males [16,24]. Surprisingly we found a significant proportion of males among adolescents with headache, mainly in the subgroup of mild headaches. This might be due to the fact that this symptom, based only on subjective reports, might be overestimated by the adolescent conscript who, upon undergoing a meticulous screening before the military recruitment, tends to pay more attention to some body perceptions.

Epilepsy constituted the third most common neurological disease in our study (1.67%). This prevalence is somewhat higher than the 0.35–0.86% reported in the literature [5, 7].

The broad group of movement and coordination disorders had a prevalence of 0.36% and was much more common in males. This group also included attention deficit hyperactivity disorder and tic disorders which are recognized more often in boys [8, 13, 18, 20, 26]. However, the summary reports of the health statistics for US children by the National Health Interview Survey reported that about 7% of children aged 3–17 years have ADHD [3]. This difference might be due to the fact that our population comprised a narrow age group (16–18-year-olds) for whom a mild form of attention deficit disorder which did not substantially interfere with school activities and might therefore have been overlooked in childhood and “grown out” by the age of pre-military evaluation. In a similar fashion, mild tics in early childhood might have escaped medical attention.

In some previous studies, insomnia was found in about 4.7–35% of adolescents, representing a higher proportion than the 0.14% found in our study [1, 12, 17, 22, 23, 25]. Previous studies investigating insomnia used detailed questionnaires that may have detected minor sleep disturbances (like early awakening) missed by our screening methods. Moreover, the period (asking about sleep disturbances in the last year) referred to in reported studies might be in part responsible for the larger number of adolescents who were diagnosed with insomnia. In our study, teenagers who complained about sleep disturbances underwent polysomnography recording, which very likely ruled out many cases of alleged insomnia.

Finally, chronic and progressive diseases of the central nervous system were least common (0.08%). This was expected, since most of the disorders in this group, such as cerebrovascular diseases, demyelination, tumors, and encephalopathies typically occur in adults.

Despite the obvious limitations, mainly the grouping of neurological diseases, the importance of this study relies on the fact that screening was performed in an almost entire population. Therefore, it provides significant information that enriches the estimation of the prevalence of neurological diseases in adolescents. It also demonstrates some important epidemiological trends.

The use of the data for academic research and the publication of this study were approved by the IDF medical corps.

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