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TRAUMATIC BRAIN INJURY IN NORTHERN SWEDEN

Incidence and Prevalence of Long-standing Impairments and Disabilities

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ABSTRACT. Based on a retrospective survery of hospital admissions and autopsies the incidence of traumatic brain injury (TBI) for the age range 16–60 was found to be 24.9/10 000 in the Umeå district of Northern Sweden. In male youngsters aged 16–19 the incidence was remarkably high in comparison with reports from other parts of the western hemisphere. Self-reports on the prevalence of impairments and disabilities 1 1/2–3 years after the injury were obtained by a mailed questionnaire. Among the subjects with brain concussion 1/3 reported impairments and 1/10 disabilities, most commonly leisure-disability. By factor analysis impairments and disabilities could be logically grouped into three factors. Two of these factors clearly circumscribed combinations of impairments and disabilities, one of them being dominated by instrumental ADL, the other by basic self-care ADL. The third factor incorporated the classic post-concussion triad and memory. Taken together the findings indicate that many subjects with an early diagnosis of brain concussion, hospitalized for only one day, experienced losses in pre-injury functions and abilities. It is therefore suggested that not only radiologically and/or operatively confirmed TBIs but also subjects with brain concussion should be followed after discharge in order to minimize losses in social well-being.

Key words: traumatic brain injury, brain injury, brain concussion, incidence, impairment, disability.

The consequences of traumatic brain injury (TBI) have attracted increasing interest within the field of rehabilitation medicine. A lack of epidemiologically anchored investigations describing prevalences of impairments and disabilities after such injuries does, however, generally preclude the calculation of resources needed for the rehabiliation of these patients.

This investigation was therefore designed as a survey of the incidence of TBI in the district of Umeå, Northern Sweden. Moreover, prevalence of long-standing impairments and disabilities was registered at least 1 1/2 years after the injury.

METHODS

The target population was aged 16–60, living in the Umeå district (Fig. 1). The land area of this district is approximately 9 350 km^2. The total population of the area in December 1984, which marked the half-way stage of the present investigation, was 118 000. Of these, 70 000 (59%) were aged between 16 and 60. The major part of the population lives and works in the city of Umeå (population approximately 85 000). The city is situated on the Gulf of Bothnia. A typical educational and administrative centre, about 50% of the adult population of Umeå is employed within the public sector and 20% within industry and construction. The average age in this city is somewhat lower than that of the rest of Sweden. The 16–60 age range was chosen because subjects with impairments and/or disabilities in this age range usually qualify for referral to the regional hospital's Department of Rehabilitation Medicine. Furthermore, subjects older than 60 were excluded because with increasing age cerebral functioning, for instance perception (1), has been commonly found to decrease somewhat, thus possibly giving spurious results concerning impairments and disabilities.

In this investigation TBI was physician (or in some cases autopsy-) diagnosed and implied symptoms of impaired brain function due to trauma. The diagnoses surveyed were: 850.00–854.00 (cf. 3).

Survey of incidence. All subjects who had been admitted to the hospital during the period April 15, 1984–October 14, 1985 with a traumatic brain injury (850–854) were identified. Jennett & Macmillan (4) have favoured this method for comparing incidences in different geographical areas. Moreover, the files of the department of forensic medicine were examined in order to identify those subjects (aged between 16–60) who, brought in deceased or who died within hours in the emergency room, had a traumatic brain injury. The (very few) subjects who had sustained more than one brain injury during the studied period (in these cases only ICD number 850)—for instance some icehockey players—were only counted once.

Prevalence of impairments and disabilities. Reports of impairments and disabilities were obtained through a structured

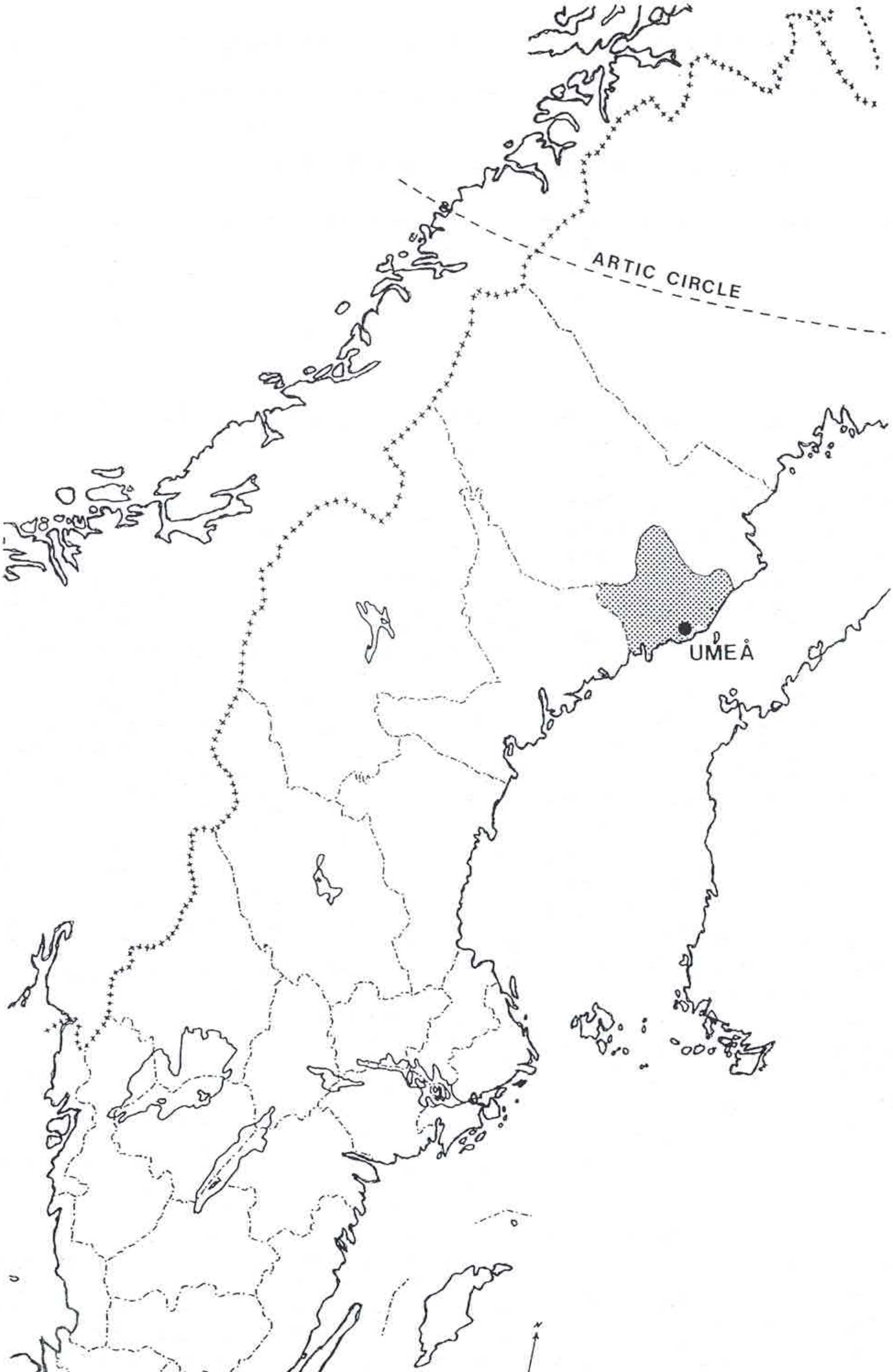

Fig. 1. Sweden showing the geographical position of the Umeå district.

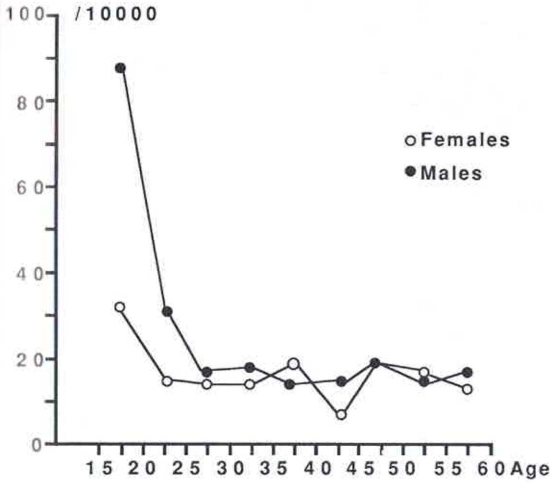

Fig. 2. Calculated age-cohort corrected incidence of hospitalized subjects with traumatic brain injury in the Umeå population in the mid-1980s.

(yes/no answers) questionnaire, which, 1 1/2–3 years after the injury, was mailed to all subjects identified in the incidence survey. Subjects were asked to answer affirmatively only if impairments or disabilities were regarded by them as a consequence of the brain injury *per se.* The items were: impairments: mobility arms/legs; balance; coordination; speech/reading/writing; dizziness; light/sound hypersensitivity; headache; memory. Reported disabilities were: transfers, hygiene, dressing, eating/drinking (all self-care ADL items), homemaking, leisure, vocation.

Statistics. Pairs of variables were compared by simple cross-tabulations. The chosen level of significance was $p < 0.05$. To deduce whether a pattern of functions/impairments and abilities/disabilities occurred, a factor analysis was used, entering all 15 items listed above. Only factors with Eigenvalues ≥ 1.0 were considered worthwhile to consider. The chosen cut-off value for a rotated loading (varimax) to be regarded as having a significant contribution to a factor was 0.5. All computations were performed on a Macintosh SE using SYSTAT®.

RESULTS

Fourteen subjects (12 men and 2 women) were deceased on arrival/or died within some hours. Five of these had a open brain injury (gunshot, 3; dynamite explosion, 1—all 4 suicides; and 1 motorcycle accident). Only for the man who committed suicide using explosives were there several causes of death including brain injury. Among the remaining 8 very early deaths, 6 died from the TBI and 2 from medullar injury due to C: 1 or C: 2 fracture. In the total sample of subjects only one more *open* TBI was identified: a man who survived two days after (suicidal) gunshot injury.

As shown in Table I the incidence of TBI was stable with very small differences between the (two) snow-free periods and the snowy (October–April) period. The calculated total incidence of TBI in the 16–60-year-old population was 24.9 per 10 000 per year. For the brain concussions (850) the median admission time was one day (range 1–69), mean 2.5 days. In this diagnostic group the few subjects who occupied a hospital bed for more than about one week all had other traumata which motivated longer hospitalizations. Among the 851–854-group nearly half (14/29) were never actually hospitalized due to early death (see above). Among the remaining 15, all patients with diagnoses 853 and 854 also had diagnoses 851 or 852. The subjects belonging to this group were hospitalized within a range of 2 days—whereafter that subject died—up to about one year. Many of these patients were treated at the Department of Physical Medicine and Rehabilitation.

Among the *hospitalized* subjects, the overall male/female incidence ratio was 3:2. The age-cohort corrected incidence of brain concussions (850) for men and women is given in Fig. 2. As shown, the youngest 5-year cohort of men had an incidence of nearly

Table I. *Number of subjects aged 16–60 years with physician diagnosed traumatic brain injury in the Umeå district from mid-April to mid-October 1985*

Early deaths and death on arrival or within a few hours after trauma are given in brackets. The calculated incidence is also given

ICD-code (2)	April–Oct. *n*	Oct.–April *n*	April–Oct. *n*	Total	Incidence *n*/10 000/year
850	70	70	73	213	22/10 000
851–52	5 (+7)	5 (+2)	5 (+5)	29	2.9/10 000
Total	75 (+7)	75 (+2)	78 (+5)	228 (+14)	24.9/10 000

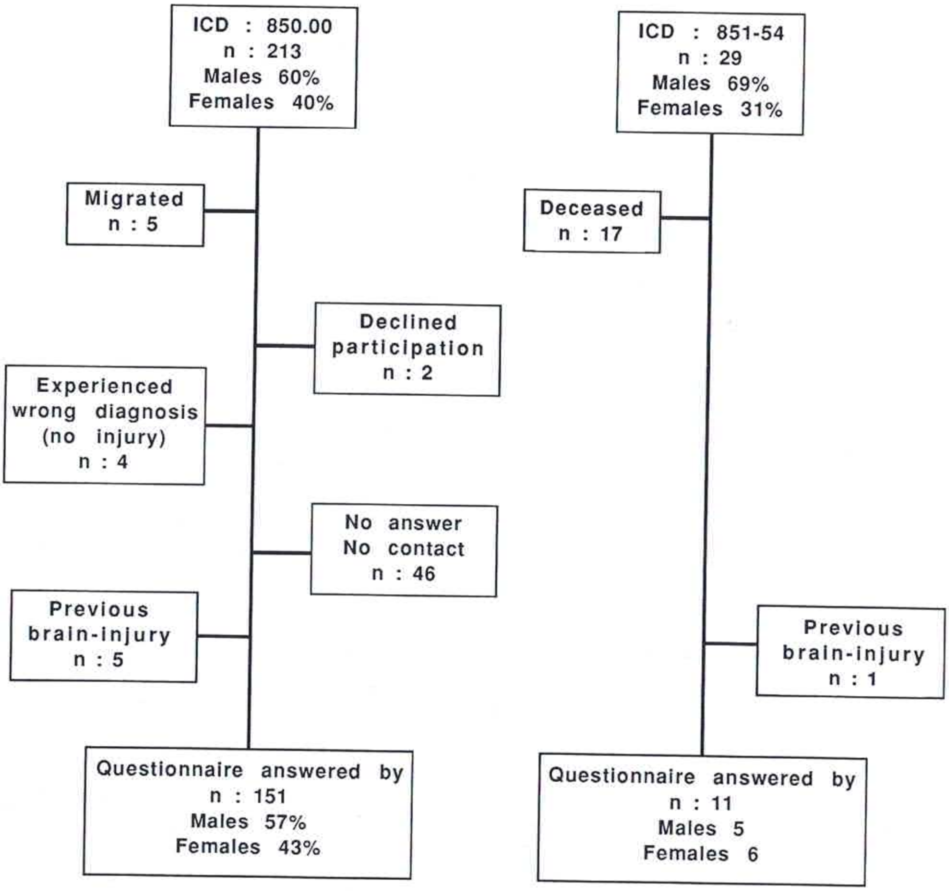

Fig. 3. The total number of subjects with traumatic brain injuries in the Umeå district and examined at the University hospital of Umeå during the period mid-April 1984 through mid-October 1985. The reasons for exclusion from the questionnaire-investigation are given.

90/10000 while the incidence for their female peers was approximately 1/3 of that and was quite similar to that of the 20–24-year-old males. From age-cohort 20–24 (women) and 25–29 (men) and up to the oldest cohort investigated, the incidence was rather stable (with minor variations) at about 17–18/10000. Hence, the greater overall male than female incidence was solely caused by the much higher incidence among the men under 25.

The follow-up questionnaire was returned by 151 (71%) of the subjects with brain concussion and by 11 of the 12 surviving subjects with diagnoses 851–854. After exclusion (cf. Fig. 3) of those who reported a previous brain injury the overall response rate was: 850: 151/208; 851–54: 11/11 giving a total of 162/219 (74%).

The prevalence of long standing (1.5–3 years after injury) impairments is given in Table II. A total of 48 subjects (32%) among the 850-group reported impairment of at least one function. The most common impairment was headache followed by decreased memory-function and by light/sound hypersensitivity. Forty subjects (26%) complained of one or more of the post-concussion syndroma ingredients: headache, dizziness, light/sound hypersensitivity (Fig. 4). Among these subjects, 18 reported only one or more of these rather non-specific symptoms, while the remaining 22 had additional impairments and/or disabilities. As shown, only 10 of these 40 subjects reported the complete classical post-concussion triad.

Furthermore, among the subjects who reported memory problems 73% had these in combination with at least one of the impairments included in the triad. Seven of the 11 subjects in the 851–854-group reported at least one of the post-concussion symptoms, and 5 reported at least two of these. Six of the

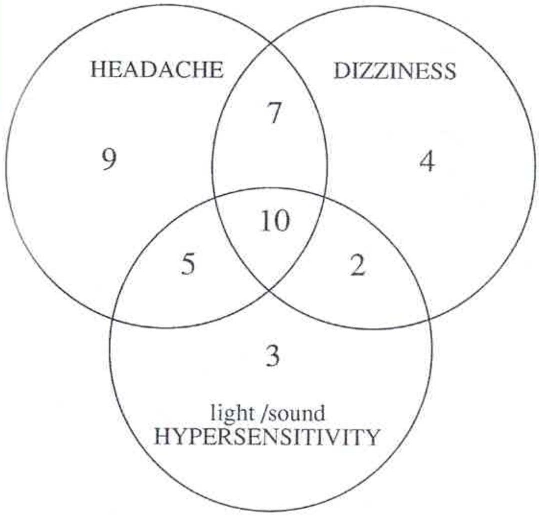

Fig. 4. Distribution of the post-concussion triad in the 40 subjects who reported any of the three symptoms at least 1 1/2 years after injury.

seven also reported memory problems. Among the remaining 4 subjects, 3 reported no impairments.

Table III shows the prevalence of disability caused (as reported) by the TBI. For the 850-group leisure disability was the most common, occurring for 9%. ADL disability in one or more of the four self-care items was reported by 8%, most commonly for transfers, while 17 (11%) reported themselves to be disabled in at least one of the aspects listed in Table III. Only one subject, however, reported disability for all listed items. Evidently the prevalence of disabilities in the 851–854-group was much higher. Four subjects reported no disabilities at all, while, on the other hand, only one subject reported disability concerning all the listed items.

The factor analyses of functions/impairments and abilities/disabilities gave three quite distinct factors, which explained 65% of the variance (Table IV). Notably, leisure was included in all of them. Factor I, which was accountable for nearly 2/3 of the variance, appeared mainly to characterize abilities requiring mobility and, to some extent, language. Factor II had the highest loadings for the "classical" post-concussion syndrome items and, with a nearly similar loading included memory. The impact on leisure of the triad dizziness/headache/light/sound hypersensitivity with concomitant experienced impairment of memory, is evident. Factor III was mainly a self-care ADL ability factor where on the one hand the importance of balance for these items of primary ADL was evident and on the other hand the importance of self-care ADL for leisure was elucidated.

DISCUSSION

Incidence. In Fig. 5 the incidence reported by other authors for the approximate age-span investigated by us is given. All investigations were performed on retrospective surveys of hospital records. It should be noted that the investigations from England and Scotland (4) and from Virginia (5) also included skull and facial fractures. The investigation by Kraus et al. (6)

Table II. *Prevalence of self-reported impairments after traumatic brain injury in a Northern Swedish population aged 16–60 years*

The numbers 850/851–52 refer to concussion/manifest brain injury (2)

Impairments	850 $n=151$ (%)	851–52 $n=11$ n (%)
Mobility arms/leg	6	3 (27)
Balance	10	4 (36)
Coordination	4	5 (45)
Language	4	4 (36)
Memory	15	7 (63)
Dizziness	11	5 (45)
Headache	22	5 (45)
Light/sound sensitivity	13	4 (36)

Table III. *Prevalence of self-reported disabilities after traumatic brain injury in a Northern Swedish population aged 16–60 years*

The numbers 850/851–52 refer to concussion/manifest brain injury (2)

Disabilities	850 $n=151$ (%)	851–52 $n=11$ n (%)
Self-care (ADL)		
Hygiene	3	2 (18)
Dressing	2	2 (18)
Eating	2	2 (18)
Transfers	6	4 (36)
Home-work	3	3 (27)
Leisure	9	6 (54)
Vocation	2	7 (64)

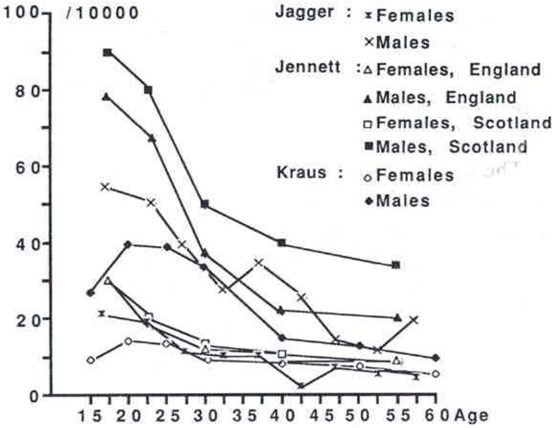

Fig. 5. Incidence of traumatic brain injury in England and Scotland (Jennett, 4) and in the USA (Jagger, 5 and Kraus, 6). Refs. 4 and 5 also include "head" injuries. The diagram is reconstructed on the basis of extrapolations from authors' diagrams.

was, on the other hand quite comparable to the present investigation. Moreover, it should be noted that the diagrams from the three investigations referred to are constructed on the basis of extrapolation from diagrams.

Quite clearly the female incidence of TBI in these parts of the world (the western hemisphere) is rather uniformly stable, not exceeding 20/10 000 after the age of about 20. For female teenagers aged between 16 and 19 the incidences in Scotland, England and Northern Sweden were nearly identical (about 30/10 000), while considerably lower incidences were found in Southern California and to some extent in an eastern part of the US.

The incidence of brain injuries in the Northern Swedish men (cf. Fig. 4) was considerably higher for the 16–19-year-old group than it was in most of the other comparable investigations, the one exception being Scotland. Remember, though, that several studies include skull and facial damages. Hence it appears that the male teenager incidence of TBI is remarkably high in Northern Sweden. We can offer no ready explanation for this fact. Tentatively it could be suggested that the high incidence may reflect the policy of referring all suspected concussions to the hospital. Moreover, the Swedish physicians seeing the subjects in the emergency room may be relatively more liberal when diagnosing a concussion in a youngster than what might be the case for physicians in the US and perhaps even in England. From the age of 20–24 the male incidence of TBI in Northern Sweden to a certain extent appers similar to that of the much warmer and much more urbanized Southern California and, as the only area (among those compared here), was by and large similar to that found in the females.

Prevalence of impairments and disabilities. Judging from the self-reports, up to 1/3 of the Northern Swedish subjects hospitalized for a brain concussion have long standing impairments which lead one to suspect that they had sustained irreparable brain damage. Moreover, about 1/10 of the concussion subjects were to some extent disabled 1 1/2 years after the trauma. Generally, however, the disabilities were rather mild as only a few subjects had experienced decreased working capacity. On the other hand the majority of the disabled reported leisure disabilities. The relatively high prevalence of impairments and/or disabilities *could* to some extent be due to spontaneous prevalence of some of the impairments/disabilities. On the other hand, and in order to minimize the risk of overestimation (unpublished observations) all subjects with the exception of those who only reported headache, dizziness and sound/light hypersensitivity were contacted by telephone and specifically asked if the

Table IV. *Rotated (varimax) loadings and Eigenvalues for factor analysis of 15 functions/impairments (1) and abilities/disabilities (2) reported by 162 individuals*

The explained variances are also given

	Factors		
	I	II	III
Headache[1]	0.0	0.8	0.1
Dizziness[1]	0.1	0.8	0.1
Light/sound hypersensitivity[1]	0.2	0.8	0.0
Memory[1]	0.1	0.7	0.2
Language[1]	0.5	0.4	0.3
Coordination[1]	0.5	0.4	0.3
Balance[1]	0.2	0.5	0.5
Mobility[1]	0.8	0.1	0.1
Transfer[2]	0.4	0.4	0.5
Hygiene[2]	0.1	0.2	0.9
Dressing[2]	0.3	0.1	0.9
Eating/drinking[2]	0.8	0.0	0.3
Home-making[2]	0.8	0.3	0.1
Work[2]	0.8	0.3	0.3
Leisure[2]	0.5	0.5	0.5
Eigenvalue	2.2	6.3	1.3
Per cent variance explained	42.0	14.4	8.7
Total variance exp.	65%		

impairment(s)/disability(ies) was/were due to the accident. All of them re-iterated their previously mailed answer.

That 26% reported at least one of the symptoms: headache, light/sound hypersensitivity and dizziness—is clearly more than that found by Rutherford et al. (7) who in a one year follow-up of 131 patients with brain concussion found that 14.5% had symptoms of this kind. As the subjects ($n=18$) who reported *only* these symptoms were not contacted by telephone a certain risk of over-estimation of long-term sequelae exists, i.e. some of the subjects may—in spite of the instructions in the questionnaire (cf. methods)—have reported "spontaneous", not TBI-related, symptoms of this kind. In congruence with our findings, Rutherford et al. (7) found headache to be the most common symptom (11/19). However, in the present investigation headache was relatively more common.

One feature of this investigation is that by factor analysis all functions/impairments and abilities/disabilities included in the questionnaire had significant contributions to the three-factor pattern. One of these factors (II) validates the concept of a post-concussion syndrome. Even from the statistical point of view it therefore appears relevant to respect the triad as a valid entity which is equally dominated by all three post-concussion items. The fact that 73% of the subjects in the 850-group, who reported memory problems, had one or more of the three impairments associated with the post-concussion triad, and also the quite distinct factor which combined these three items with memory problems, indicate that the post-concussion syndrome should furthermore include memory deficits.

Factor III mainly characterizes basic self-care ability. Low factor scores within this factor characterizes the self-care dependent brain injured subject. The third of the three factors can primarily be regarded as a descriptor of subjects' capacity to manage instrumental ADL; which, in turn, is based upon mobility and communication. The factor analysis demonstrates that the post-concussion syndrome is not particularly closely related to ADL. On the other hand the factor analysis also separates self-care from instrumental ADL. Finally, the finding that leisure-ability was included in all three factors confirms previous findings that leisure activities are particularly sensitive to impairments and to self-care disabilities after traumatic brain injury (2, 8).

It appears quite common to classify brain injuries into categories such as severe, moderate and mild. From the occupational therapist's/rehabilitationist's point of view, such a classification is rather dubious. The patient who cannot any longer participate fully in previous leisure and vocational activities due to a "mild" brain injury may have lost much of the meaning in his or her life. In particular memory problems are difficult to cope with. Therefore, on the basis of the present findings, we suggest that *all* patients with a TBI, even the mildest ones, should be followed carefully with at least an assessment of his or her abilities to pursue vital goals. Such an assessment might best be performed some months after discharge, and perhaps most adequately by an occupational therapist.

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