The prevalence, course and clinical features of post-concussion syndrome in children

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Key words: *mild traumatic brain injury, children, post-concussion syndrome.*

Summary. *Objective. To investigate the clinical features and the prevalence of symptoms of post-concussion syndrome in children with mild traumatic brain injury, and to evaluate their changes over time.*

Material and methods. The research involved two groups of 4–16 year-old children: the case group of 301 children who had experienced a single mild traumatic brain injury, and the control group of 301 children who had sustained any other mild body injury without head trauma. Groups were matched according to gender, age, and the date of admission to hospital. In total, 102 matched pairs were analyzed. The period between the date of the trauma and the examination was one to five years (median – 27 months). Standartized questionnaires were sent by post to parents from both groups. Parents were asked about the health state as well as symptoms of post-concussion syndrome, their character and frequency. The respondents were inquired about the presence of the symptoms prior to the trauma, shortly after the trauma, and during the last year and the last month before the inquiry.

Results. The prevalence of headache, irritability, fears, sleep disorders, learning difficulties, as well as concentration and memory problems did not differ significantly between children with mild traumatic brain injury and the control group when the results of the last year before examination and the last month before the examination were compared. We have investigated how the period of time between the date of the trauma and the date when the questionnaire was filled in influenced the results. The comparison of the questionnaires that were filled a year (but less than two years) after the trauma to those that were filled in 2–5 years after the trauma revealed significant differences in the prevalence of a number of symptoms of the post-concussion syndrome. In children with mild traumatic brain injury, there was a significant decrease in the prevalence of learning difficulties soon after the trauma ($p=0.032$), headaches before ($p=0.026$) and soon after the trauma ($p=0.01$), and irritability the last month before the examination ($p=0.043$). In children from the control group, there was a significant decrease in the prevalence of concentration problems the last year before examination ($p=0.023$) and the last month before examination ($p=0.036$).

Conclusions. More than one year after the trauma, the prevalence of the symptoms of the post-concussion syndrome is not significant higher in children with mild traumatic brain injury, compared to children with other mild body injuries, and is comparable by the changes over time.

Introduction

In the USA, each year 80,000 to 120,000 pedestrians sustain head traumas, of which 4,600 to 4,900 are fatal. The highest risk groups are children aged 5 to 9 years, and the elderly over 80 years of age (1). One hundred and eighty children per 100,000 population suffer closed head injuries yearly, 80% of these cases being classified as mild cerebral injuries (2). There are numerous reliable data indicating that moderate and severe head traumas result in cognitive, learning, psychological, and social problems (3–5), although the consequences of mild head traumas are still disputed (6–8). It is assumed that mild cerebral traumas do not entail long-term consequences in children (9–10). However, existing data that moderate and severe traumas have more negative effects on the brain of young children revived speculations that mild traumas may also have long-term consequences (3–6, 11). On the other hand, another opinion exists that the smaller the child is, the higher plasticity of the brain, and the faster regeneration of damaged cerebral structures (12).

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Studies on children who sustained mild cerebral traumas show that during the first days after the trauma children experience headaches, as well as cognitive and behavior problems (13), but shortly after this these symptoms disappear (14). A part of children continue to experience disorders in concentration, performance speed, memory, and behavior (15). Some studies point these disorders back to the problems that existed prior to the trauma (16, 17), while others attribute them to psychogenic causes (18, 19).

Symptoms that people frequently complain of after mild head trauma are defined as the post-concussion syndrome. Such symptoms include headache, dizziness, disorders of attention, memory, sleep, learning, and concentration, fatigue, emotional instability, mood swings, anxiety, and fears. All these symptoms are defined in the International Classification of Diseases (ICD) (20).

It is important to find out how often complaints like that should be attributed to the sequelae of mild traumatic brain injury, and how the experienced trauma influences the child's health, especially over time (18).

The aim of our study was to determine the clinical peculiarities, prevalence, and time-related changes of the symptoms of post-concussion syndrome in children who experienced mild traumatic brain injury.

Material and methods

We compiled two groups of children of the patients who within the period of 1997–2001 applied for urgent help to the emergency room or the outpatient department of Kaunas University of Medicine Hospital or Kaunas Red Cross Hospital: 301 children (aged 4–16 years) who for the first time experienced mild traumatic brain injury, and 301 children who experienced other types of mild injury (i.e. bruising of the limbs, abrasions, or sprains) without head trauma. Parents or caregivers of children of both groups received the following material by post: a letter informing about the study, an Informed Consent form about the participation in the study (to be signed by the participant), and a standardized questionnaire on the children's previous and present health condition, as well as irritability, fears, sleep disorders, learning problems, concentration problems, memory disorders, and headaches and concomitant symptoms prior to the trauma, shortly after the trauma (only in the case group), during the last year, and during the last month before the inquiry (in both groups). In order to avoid the parents' biased attitude towards the experienced trauma, the familiarization letter and the first questionnaire on the children's present (during the last month before the filling of the questionnaire) and past (during the last year before the filling of the questionnaire) health condition did not mention the trauma explicitly. Upon the reception of the filled questionnaire, the second questionnaire was sent inquiring parents of both children groups about their children's sustained head traumas. Parents of the case group were additionally asked about their children's health condition before and shortly after the trauma. The time-related changes in the symptoms were verified in two different ways: 1) the comparison of the prevalence of the symptoms during different time periods (prior to the trauma, shortly after the trauma, during the recent year, and during the last month before the inquiry), and 2) the verification according to the distance in time between the date of the trauma and the date of the inquiry. Further analysis excluded the cases where a child from the case or the control group appeared to have experienced mild traumatic cerebral injury that was not known prior to the treatment; incompletely filled questionnaires or cases that did not have pairs were excluded as well. After the final re-matching, 102 matched pairs were selected. A wider description of the contingent and the methods of the study are presented in our previous article (21).

The study protocol, the questionnaire, and the Informed Consent form were adapted to children according to a similar study performed in the adult population (22), and were confirmed by the Bioethics Committee of Kaunas University of Medicine.

Statistical analysis. In order to compare statistical distributions of the studied variables, the χ^2 criterion was applied. The comparison of the mean values was performed using Student's t test. The analysis of the data of the matched pairs, and the comparison of the results of the repeated inquiry were performed using McNemar's test. The analysis of the data was performed using SPSS and EPIINFO statistical software packages. The results were considered to be statistically significant when $p<0.05$.

Results

In each group (102 subjects in each the case and the control group), matched pairs consisted of 28 girls (27.5%) and 74 boys (72.5%). There were no differences between the case and the control groups concerning the demographical and general health characteristics of the children and their families.

We analyzed the dynamics of the prevalence of headaches in the studied groups. The question "did your child experience headaches prior to the trauma?" was positively answered by 48 parents in the case group (47.1%), and headaches shortly after the trauma were indicated by 72 parents (70.6%) (Fig. 1, p=0.01). Forty-four children (43.1%) had headaches both before and shortly after the trauma, 54 children (52.9%) did not complain of headaches prior to the trauma, and in 28 (51.9%) of them headaches appeared shortly after the trauma. The com-

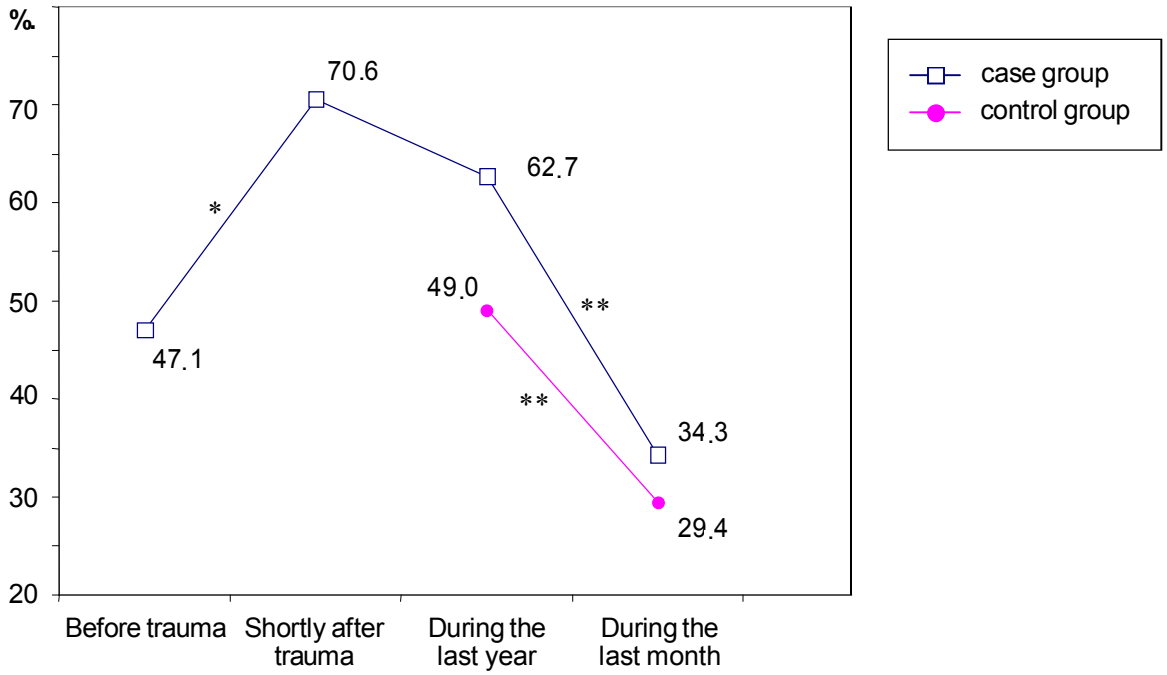

Fig. 1. **Changes in the prevalence of headaches in the case and the control groups**
*p=0.01; **p=0.001.

parison of the studied variables shortly after the trauma and during the last year before the inquiry yielded no statistically significant differences (headaches disappeared in 17 children (28.3%)). However, the comparison of the situation shortly after the trauma with that during the last month before the inquiry, and the comparison of the situation during the last year with that during the last month before the inquiry showed a statistically significant decrease in the prevalence of headaches (Fig. 1, p=0.001).

In the control group, headaches during the last year before the inquiry were experienced by 50 children (49%), and during the last month before the inquiry – by 30 (29.4%) children, which indicates a statistically significant change (Fig. 1, p=0.001).

The comparison of the data of the case and the control groups between the last year and the last month before the inquiry did not show any differences in the prevalence of headaches.

The question "did your child become irritable shortly after the head trauma?" was positively answered by 46 parents (45.1%) in the case group. When asking the parents in both the case and the control groups about the children's irritability during the last month before the inquiry, trauma was not mentioned as a cause; the question was divided into two: "is your child sensitive about noise and strong sounds?", and "does your child easily get irritated?". The prevalence of irritability (reaction to noise and rapid irritation) in the case group did not differ after the trauma and during the last month before the inquiry. No differences in the irritability during the last month before the inquiry between the case and the control groups were found either.

The question "did your child start to experience fears shortly after head trauma?" was positively answered by 15 (14.7%) parents in the case group. When asking about fears experienced during the last year before the inquiry, the trauma was not mentioned as the cause. Twenty children (19.6%) in the case group experienced fears during the last year before the inquiry, while in the control group the number was 21 (20.6%). The comparison of the data on fears experienced during the last year and the last month before the inquiry showed that the proportion of children who experienced fears was statistically significantly lesser in both the case (p=0.001) and the control groups (p=0.001). No difference between the two groups during the last month before the inquiry were found.

The question "did sleep disorders occur in your child shortly after head trauma?" was positively answered by 17 (16.7%) of the parents in the case group. The comparison the responses about sleep disorders experienced during the last year and the last month before the inquiry showed a statistically significant decrease in the proportion of children with sleep disorders in both the case (p=0.039) and the control (p=0.049) groups. No differences between the case and the control groups were found concerning sleep disorders during the last month before the inquiry.

The proportion of children with learning difficulties statistically significantly (p=0.001) increased from the

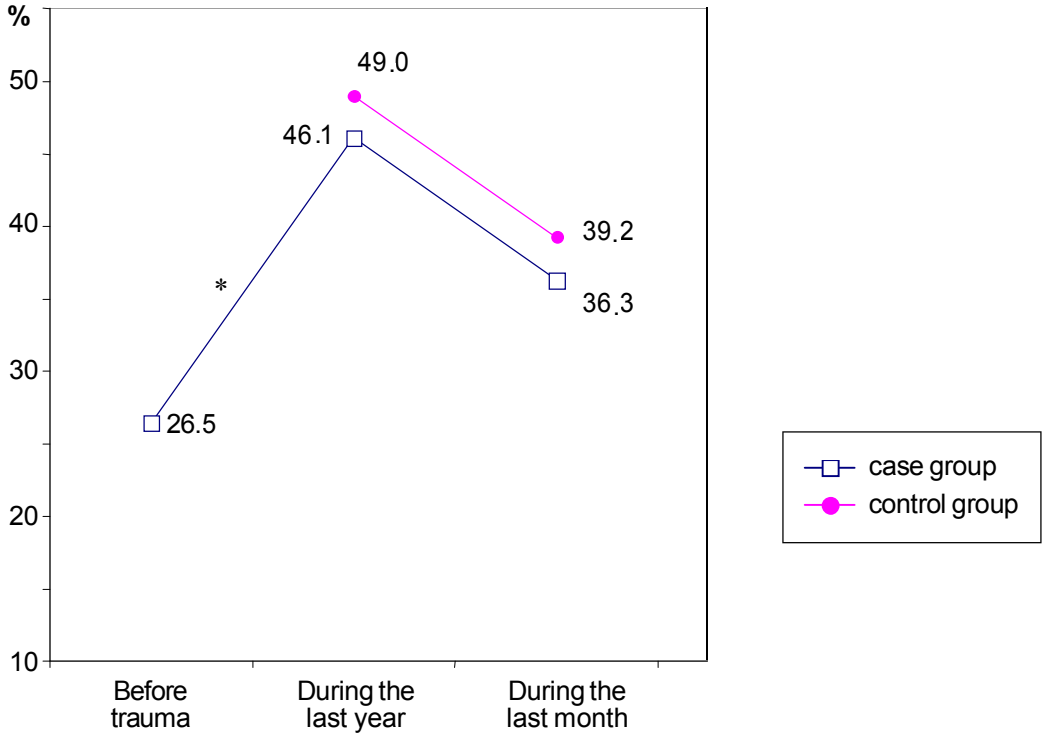

Fig. 2. **Changes in the prevalence of learning difficulties in the case and the control groups**
*p=0.001.

period shortly after the trauma (27 children (26.5%)) to the last year before the inquiry (47 children (46.1%)) (Fig. 2, p=0.001).

The question "did your child start to experience learning difficulties shortly after the trauma?" was negatively answered by 76 (74.5%) parents in the case group, and 26 (25.5%) parents stated that their children started to lag behind a little. No differences between the case and the control groups were found during the last year or the last month before the inquiry. The distributions of both the case and the control groups according to the learning programs were similar: 81 (79.4%) and 89 (87.5%) children, respectively, learned according to the general curriculum, 17 (16.6%) and 11 (10.5%) children – according to the advanced curriculum, and 4 (4%) and 2 (2%) children, respectively, learned according to the adapted curriculum or at home.

The comparison of the case group parents' answers to the question "does your child have difficulty in concentration?" before the trauma and during the last year before the inquiry (without mentioning the trauma as the cause) showed a statistically significant difference (Fig. 3, p=0.001). No differences between the case and the control groups were found in this respect either during the last year or during the last month before the inquiry.

The analysis of memory disorders in the case group before the head trauma and after it during the last year before the inquiry yielded a statistically significant difference (Fig. 4, p=0.01).

According to the parents' opinion, the proportion of children with memory problems increased from 9.8% before the trauma to 25.4% after the trauma (respectively, 10 and 26 children). The distributions in the case and the control groups did not differ either during the last year or the last month before the inquiry.

According to the time interval between the date of the trauma and the date of the filling of the questionnaires, we divided the questionnaires into those filled more than a year, but less than two years after the trauma (50 questionnaires, 23 – in the case, and 27 – in the control group) and those filled later, i.e. 2–5 years after the trauma (154 questionnaires, 75.6%). We analyzed how the results of the questionnaire were influenced by the time interval between the trauma and the filling of the questionnaire.

In the case group, among children for whom the questionnaire was filled more than a year, but less than two years after the trauma, 10 (43.5%) children experienced learning difficulties shortly after the trauma, and among those for whom the questionnaire was filled later – 16 children (20.3%); the difference was statistically significant (p=0.032). In the case group, among children for whom the questionnaire was filled more than a year, but less than two years after the trauma, the question "did your child have headaches prior to the trauma?" was positively answered in 8 (34.8%) cases, and among those for whom the questionnaire was filled later – in 10 (12.7%) cases; the difference was statistically significant (p=0.026). In the case group, among children for whom the questionnaire

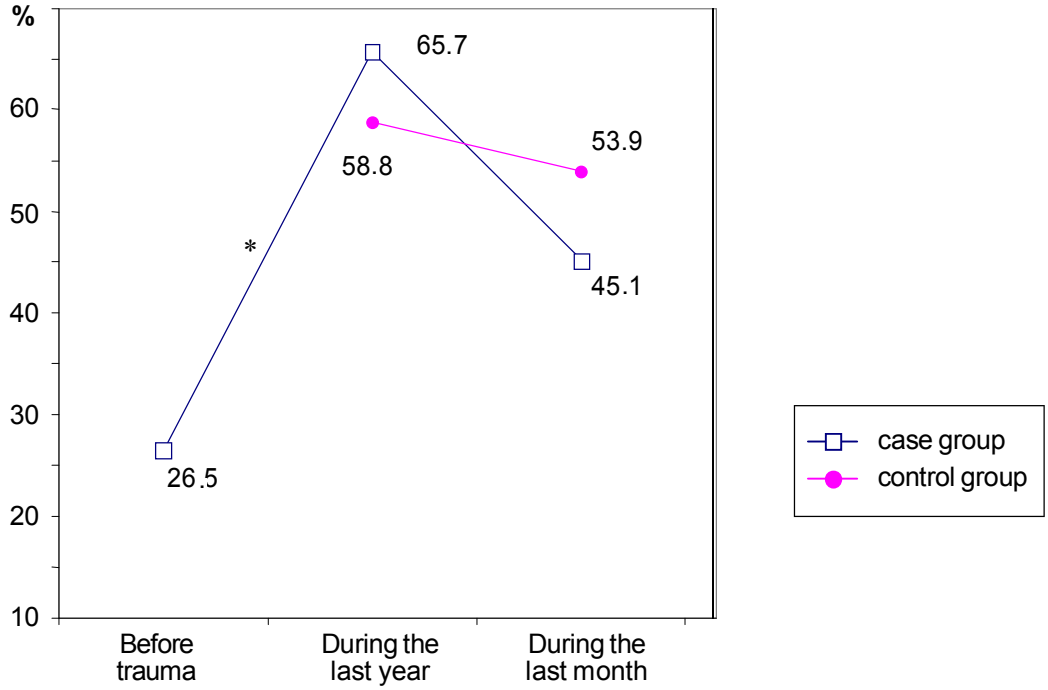

Fig. 3. **Changes in the prevalence of concentration problems in the case and the control groups**
*p=0,001.

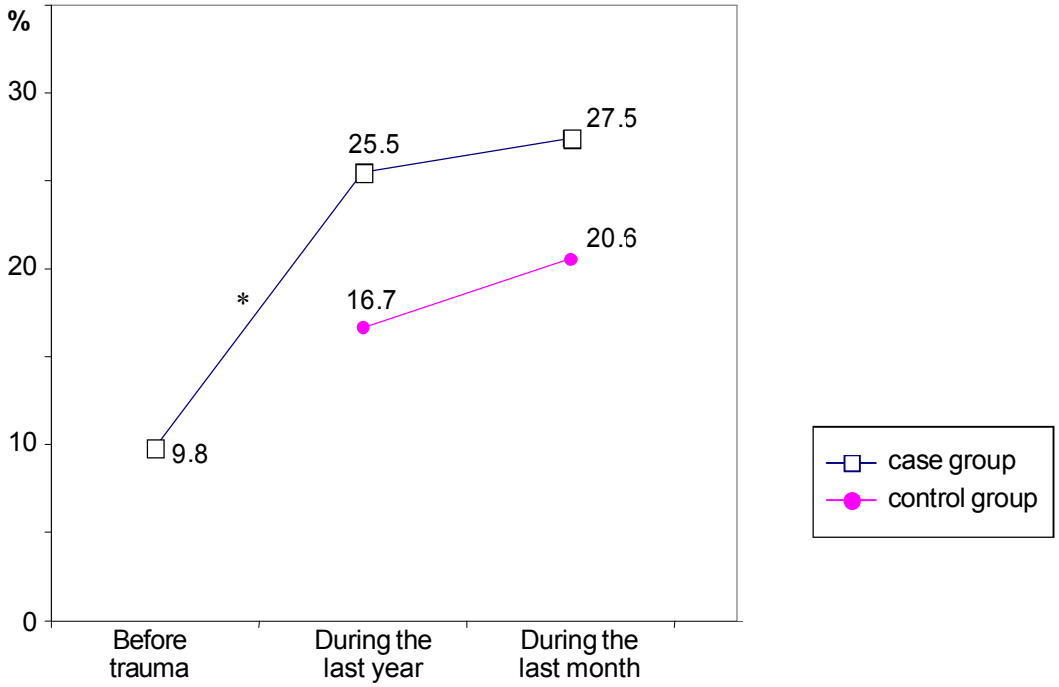

Fig. 4. **Changes in the prevalence of memory disorders in the case and the control groups**
*p=0,01.

was filled more than a year, but less than two years after the trauma, the question on headaches experienced shortly after the head trauma was positively answered in 21 (91.3%) cases, and among those for whom the questionnaire was filled later – in 49 (62%) cases; the difference was statistically significant (p=0.01). In the case group, among children for whom the questionnaire was filled more than a year, but less than two years after the trauma, the question "is your child more irritable (gets rapidly irritated, is more sensitive about noise or strong sounds)?" during

the last month before the inquiry was positively answered in 20 (87%) cases, and among those for whom the questionnaire was filled later – in 51 (64.6%); the difference was statistically significant (p=0.043).

In the control group, among children for whom the questionnaire was filled one year after the trauma, the question "did your child have concentration problems during the last year before the inquiry?" was positively answered in 21 (77.8%) cases, and among those for whom the questionnaire was filled later – in 39 (52%) cases; the difference was statistically significant (p=0.023). In the control group, among children for whom the questionnaire was filled more than a year, but less than two years after the trauma, the question "did your child have concentration problems during the last month before the inquiry?" was positively answered in 9 (33.3%) cases, and among those for whom the questionnaire was filled later – in 11 (14.7%) cases; the difference was statistically significant (p=0.036). With respect to other symptoms, we did not detect any influence of the time interval between the trauma and the filling of the questionnaire in either of the two groups.

Discussion

Two-thirds of head traumas in childhood and adolescence are experienced by males (23). According to our findings, two-thirds of the subjects who had experienced mild cerebral injuries were also males. Since the effects of repeated brain injuries (i.e. the effect of the traumas on the brain) are to be summed up (24), especially if the period between repeated head traumas is merely several months (25, 26), we excluded the children who had experienced more than one head trauma. Due to this reason, both of our groups significantly decreased, but this allowed us to avoid repeated head trauma-related bias in the interpretation of the findings.

Our study showed that the symptoms that are frequently considered to be a necessary manifestation of post-concussion syndrome (headaches, memory or sleep disturbances, insufficient concentration and its maintenance, learning difficulties, irritability, or fears) were neither objective nor specific, since there was no significant difference between the prevalence of these symptoms during different periods after the trauma among children who experienced mild traumatic cerebral injury, and among those who experienced other types of injury without head trauma. This is because headache, forgetfulness, fatigue, irritability, anxiety, fears, and sleep disorders manifest themselves in the general population as well. Meanwhile, the common attitude in the society is that these symptoms would necessarily occur as a consequence of head trauma. Stress due to the experienced trauma (the circumstances of which the victim frequently does not remember), preoccupation with the health condition, anxiety related to possible brain injury, and worry about the importance of the symptoms maintain a selective attention to the internal condition. These factors magnify the real symptoms. This is a psychological mechanism that explains why the post-concussion syndrome occurs and persists after the disappearance of the cognitive function impairment (20). Prevention of the psychological factors includes information protocols that provide the parents and their children with the possibility to learn about what can be expected after a mild traumatic cerebral injury, thus decreasing psychological tension caused by possible damage to the nervous system, and preventing the attribution of health disorders to the experienced trauma (27, 28).

It is interesting to note that the majority of parents whose children had sustained mild cerebral brain injuries indicated that their children during the year of the study had learning difficulties, as well as memory and attention disorders. The memory problems and attention disorders prior to the trauma, and learning disorders shortly after the trauma seemed to have been significantly milder, compared to the last year before the inquiry (i.e. during the year of the study), and this difference was found to be statistically significant. However, the comparison of the complaints during the last year and the last month before the inquiry in groups of children who had sustained mild cerebral brain injury, and those who had sustained other mild body injuries showed no significant difference in the prevalence of such complaints. This allows for stating that the aforementioned symptoms among children who had sustained mild traumatic cerebral injury are of an accidental character. A number of complaints of attention and memory disorders, and learning problems may be possibly related to a typical increase in the incidence of such disorders during the adolescence, especially in boys who were in the majority in our studied group. To others, the memory of such children seems weak, although forgetfulness in this case is due to attention deficits. Children who sustained mild cerebral injury usually do not demonstrate poorer results at school, but distraction and agility may be treated as laziness or unwillingness to learn, and thus the child may be misunderstood, undeservedly punished, or isolated (27). On the other hand, sufficient learning abilities of such children are proven by the fact that the majority of the children in both the case and the control groups learned according to the general curriculum. There was no difference in the proportion of children who learned according to the advanced curriculum between the two groups either. Analogous results were obtained by A. McKinlay et al. in their 2002 case-control study of children who had sustained mild cerebral brain injury being up to 10 years of age, and including their prospective follow-up until adolescence. No learning difficulties were detected, irrespectively of the age of the child when the trauma occurred (18).

By dual testing of the duration of the symptoms, we have proven that symptoms, if they exist, do not tend to be long lasting. The fact that a higher prevalence of the symptoms is reported during the last year before the inquiry, compared to the last month before the inquiry, may be explained in two ways: this can show that the symptoms tend to reduce with time, or that their frequency during the year was so low that they simply did not occur during the last month before the inquiry.

Our findings can be compared to those obtained by J. Ponsford *et al.* in their 1999 case-control study (29), where they found that children suffer from headache, dizziness, and fatigue during the first week after the mild traumatic cerebral injury – the symptoms that were not observed in the control group. According to our findings, one-half of the children experienced headaches shortly after the mild traumatic cerebral injury, but during the later period, the number of such children significantly decreased, and the prevalence of headaches among them did not differ significantly from that in the control group. According to the findings of J. Ponsford *et al.* (29), 17% of children had continuous problems for 3 months after the trauma, but this was either their second mild traumatic cerebral injury, or they had experienced previous learning problems, other neurological or mental disorders, or stresses within the family. It seems that children with such risk factors are more likely to experience the post-concussion problems. These findings are also confirmed by the studies performed by R. F. Asarnow (14), and P. E. Bijur and M. Haslum (17). P. Satz *et al.* in their review on mild traumatic cerebral injury write that the analysis of a number of studies allows for stating that mild traumatic cerebral injury may be followed by transient cognition disorders, but there are no reliable data on the presence of learning, psychological, or social problems (7).

We have also proven the influence of the time factor in another way, i.e. by analyzing the changes in the prevalence of complaints with respect to the time period between the traumatic event and the inquiry. The longer the period since the trauma, the fewer complaints were reported by the children's parents. The number of the children's incidental complaints that their parents attributed to the sequelae of mild traumatic cerebral injury was lesser as well. This could be associated with the decrease in the severity and the frequency of the experienced symptoms. However, this temporal factor may also be related to psychological reasons. The longer the period after the trauma, the lesser the parents' anxiety related to the child's possible cerebral injury.

Conclusions

The prevalence of headache increases shortly after the traumatic cerebral injury. However, with time it decreases, and after one year following the traumatic event equals to that in the control group of children who had sustained other mild traumatic injuries. The prevalence and the time-related fluctuations of irritability, fears, learning problems, and sleep, memory, and attention disorders do not differ between the case and the control groups. All the aforementioned symptoms tend to weaken with time. The prevalence of symptoms reported by the parents was found to be in negative correlation with the time interval after the experienced traumatic event. Thus, the aforementioned symptoms may not be considered to be reliable criteria of the long-lasting post-concussion syndrome.

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Pokomocinio sindromo simptomų paplitimas, eiga ir klinikinės ypatybės vaikams

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Raktažodžiai: lengva galvos smegenų trauma, vaikai, pokomocinis sindromas.

Santrauka. Tyrimo tikslas. Nustatyti pokomocinio sindromo simptomų klinikines ypatybes ir paplitimą tarp lengvą galvos smegenų traumą patyrusių vaikų, įvertinti šių simptomų kitimą.

Tyrimo medžiaga ir metodika. Sudarytos dvi 4–16 metų vaikų grupės: tiriamoji – 301 vaikas, pirmąkart patyręs lengvą galvos smegenų traumą, kontrolinė – 301 vaikas, patyręs kitokį lengvą kūno sužalojimą be galvos traumos. Grupės suderintos pagal lytį, amžių bei kreipimosi į gydytojus datą. Sudarytos 102 suderintos tiriamųjų poros. Laikotarpis tarp traumos ir apklausos datų buvo 1–5 metai, šio laikotarpio mediana – 27 mėnesiai. Abiejų grupių tėvų apklausa apie vaikų sveikatos būklę, įskaitant pokomocinio sindromo simptomus, šių simptomų klinikines ypatybes, paplitimą vyko paštu naudojant standartizuotą klausimyną. Tėvų klausta apie simptomų buvimą iki traumos, netrukus po traumos, paskutiniais metais bei paskutinį mėnesį iki apklausos.

Rezultatai. Galvos skausmų, dirglumo, baimės, miego sutrikimų, mokymosi sunkumų, sunkumų susikaupti, atminties

sutrikimų paplitimas tarp lengvą galvos smegenų traumą patyrusių vaikų palyginus su kontroline grupe, paskutiniais metais ir paskutinį mėnesį iki apklausos, reikšmingai nesiskyrė. Tyrėme, kaip gautiems duomenims turėjo įtakos tai, po kiek laiko nuo traumos buvo pildyta anketa. Vaikams, kuriems anketa pildyta praėjus dvejiems penkeriems metams po traumos, nustatyta statistiškai reikšmingai mažiau simptomų nei vaikams, kuriems anketa pildyta praėjus daugiau kaip metams, bet mažiau kaip dvejiems metams po traumos tiriamojoje grupėje: mokymosi sunkumų netrukus po traumos (p=0,032), galvos skausmų iki traumos (p=0,026) ir netrukus po traumos (p=0,01), dirglumo paskutinį mėnesį iki apklausos (p=0,043). Kontrolinės grupės vėliau pildytose anketose statistiškai reikšmingai mažiau nustatyta sunkumų susikaupti paskutiniais metais (p=0,023) ir paskutinį mėnesį (p=0,036) iki apklausos.

Išvados. Pokomocinio sindromo simptomų paplitimas, praėjus daugiau kaip metams po traumos, nėra reikšmingai didesnis tarp vaikų, patyrusių lengvą galvos smegenų traumą, palyginus su kitas lengvas kūno traumas patyrusiais vaikais, be to, nesiskiria simptomų pokyčiai laiko atžvilgiu.

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