S H O R T
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Minor neurological dysfunction in children aged 5 to 7

Minimalne neurološke disfunkcije kod dece uzrasta od 5 do 7 godina

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Abstract

Background/Aim. Assessment of minor neurological dysfunction (MND) provides information about a child's neurological condition which helps to identify the vulnerability of the child to the development of motor impairment, difficulties in learning or behavioral disorders. The aim of this study was to determine differences in the prevalence of MND in children from the general population with respect to age (5 and 6 years old) and sex. **Methods.** The examination was carried out in a preschool institution in the city of Novi Sad, Serbia. The total sample included 120 children divided into two groups according to age: 60 children aged 5 (group A) and 60 children aged 6 years (group B). The children were recruited at three randomly selected kindergartens and approximately equal sex representation, randomly selected as well. The testing was done by the Touwen's test, modified by Hadders-Algra. The results were classified into three groups: the absence of MND, presence of simple MND (presence of one or two domains of dysfunction) and the presence of complex MND (presence of at least three domains of dysfunction). **Results.** Sixty-seven children out of 120 (55.8%) had a normal neurological condition, while 53 (44.2%) showed MND [49 (40.8%) simple, and 4 (3.4%) complex]. MND occurred more frequently in the youngest age group than in the older children (57% vs. 32%; $p = 0.01$). MND was also more frequent in boys than in girls, but this difference was not statistically significant. **Conclusion.** Our results show the importance of testing children at preschool age in order to detect potential neurological vulnerability and timely begin with the appropriate therapy.

Key words:
neurological manifestation; risk; child; child, preschool; age factors; sex factors.

Apstrakt

Uvod/Cilj. Procena minimalnih neuroloških disfunkcija (MND) pruža informacije o neurološkom stanju deteta, štp pomaže u identifikovanju vulnerabilnosti deteta ka razvoju motornih slabosti, teškoća u učenju ili poremećaja ponašanja. Cilj rada bio je utvrđivanje razlike u učestalosti MND kod dece iz opšte populacije u odnosu na uzrast (5 i 6 godina) i pol. **Metode.** Ispitivanje je urađeno u predškolskoj ustanovi na teritoriji grada Novi Sad. Ukupan uzorak je obuhvatio 120. dece koja su bila podeljena u dve grupe u odnosu na uzrast – 60. dece starosti 5 godina (grupa A) i 60. dece starosti 6 godina (grupa B). Metodom slučajnog izbora izabrana su tri vrtića, a deca su nasumično odabrana, sa približno jednakom zastupljenošću polova. Testiranje je urađeno Touwen-ovim testom modifikovanim od strane Hadders-Algre. Rezultati su grupisani u tri grupe: odsustvo, prisustvo jednostavnih (prisustvo jedne ili dve oblasti disfunkcije) i prisustvo kompleksnih MND (prisustvo najmanje tri oblasti disfunkcije). **Rezultati.** Šezdesetsedam (55,8%) od 120. dece imalo je normalne neurološke nalaze, dok je 53. (44,2%) pokazalo prisustvo MND, 49. (40.8%) jednostavne, a 4 (3.4%) kompleksne. U mlađoj uzrasnoj grupi MND su se češće javljale nego u starijoj (57% vs. 32%; $p = 0.01$). Takođe, MND su se češće javljale kod dečaka u odnosu na devojčice, ali razlika nije bila statistički značajna. **Zaključak.** Naši rezultati pokazuju značaj testiranja dece u predškolskom uzrastu radi otkrivanja eventualnih odstupanja i blagovremenog započinjanja adekvatne terapije.

Ključne reči:
neurološke manifestacije; rizik; deca; deca, predškolska; životno doba, faktor; pol, faktor.

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Introduction

Ontogenetic changes in human CNS cause various manifestations of spontaneous behavior and provoked reactions and reflexes, depending on age. As a result, during the development of children, neurological examination technique, the obtained responses and their interpretation change with the age. The period of the most intensive postnatal development is the first year of life, but the changes in the clinical manifestations of neurological semiology are also present at preschool age and school age until adolescence [1]. The classical neurological examination does not provide a valid assessment of the neurological status during the development of children. Some neurological signs are specific to childhood. Associated movements are characteristics of childhood as well as more noticeable choreiform movements of the upper extremities or minor deviation of gait [2]. Touwen's neurological examination allows registering minor deviations in neurological condition, which may be relevant to clinical work: if there is a suspicion of neurological disease at the initial stage; in children with already diagnosed diseases such as cerebral palsy, where a more detailed insight into the neurological status would make a more adequate treatment possible; to gain insight into the state of children with difficulties in learning, attention and coordination of movements [2].

In all children, and especially children with behavioral and cognitive problems during development, the percentage of children with minor neurological dysfunction (MND) is increasing [3]. There are also differences in prevalence of MND in different generations which were examined at the same age [4]. Determining the prevalence of MND in children of different age and different generations is essential because it provides a starting point for further research relating to vulnerable groups. It is very important to test children for the presence of MND at preschool age in order to start the early treatment in time and thus reduce behavioral and learning problems at school age [5, 6].

It was noticed that in 9-year-old girls with complex MNDs and dysfunction in the domain of posture and muscle tone, there was an increased risk of developing behavioral disorders, while this did not occur in boys of the same age. In contrast, it was observed that if simple MNDs occurred in boys, there was an increased risk of nonspecific behavioral disorders, suggesting that psychological factors play an important role in boys, in contrast to girls [7].

The aim of this study was to determine the differences in prevalence of MND in children from the general population with respect to sex and age (5 and 6 years). The assumption was that MND is more common in younger children and boys.

Methods

The examination was carried out in a preschool institution in the city of Novi Sad, Serbia. The study was approved by the Ethic Committee of the Faculty of Medicine in Novi Sad on 24th October 2013. Before the examination, the children's parents or guardians gave their informed consent for the participation of their children in the study. The total sample included 120 children divided into two groups according to the age; 60 children aged 5 (group A) and 60 children aged 6 years (group B). The children were recruited at three randomly selected kindergartens and randomly selected approximately equal sex representation. The testing was done according to the Touwen's test modified by Hadders-Algra [2]. The test results were grouped into eight domains and the presence of dysfunction was determined for each of them. These eight domains are: 1) posture and muscle tone, 2) reflexes, 3) involuntary movements, 4) coordination and balance, 5) fine manipulative skills, 6) associated movements, 7) senses, 8) cranial nerve functions.

The results were classified into three groups: normal neurological condition (absence of MND), presence of simple MND (presence of one or two domains of dysfunction) and the presence of complex MND (presence of at least three domains of dysfunction).

Data were analysed using SPSS for Windows (version 15). The results for each categorical variable are presented in frequency and percentage values. For determining the prevalence of MND relative to age and sex, we used χ^2 test. For this analysis, we accepted the level of statistical significance according to the more stringent criteria ($p \leq 0.01$).

Results

Table 1 shows the basic characteristics of groups A and B.

The prevalence of MND according to the children's sex was tested by the χ^2 test of independence. After the statistical analysis, it was evident that the MND occured more frequently in boys, however, not at the statistically significant level (Table 2).

Table 1

Baseline characteristics of the children

Characteristics	Group	
	A (n = 60)	B (n = 60)
Males, n (%)	33 (55)	31 (51.7)
Females, n (%)	27 (45)	29 (48.3)
Height (cm), mean ± SD	115.72 ± 5.11	122.08 ± 5.7
Weight (kg), mean ± SD	20.47 ± 2.73	23.05 ± 3.97
Head circumference (cm), mean ± SD	50.93 ± 1.52	51.42 ± 1.48
Age, median, (range)	5y 6m (5y-5y11m)	6y 7m (6y1m-6y11m)

A – children aged 5; B – children aged 6; y – years; m – months; SD – standard deviation.

Table 2

Minor neurological dysfunction (MND) in children relation to age and sex

Groups	N	S-MND	C-MND	χ^2	*p*
A (n = 60)					
boys, n (%)	13 (21.7)	17 (28.3)	3 (5.0)	0.176	0.675
girls, n (%)	13 (21.7)	14 (23.3)	0 (0)		
B (n = 60)					
boys, n (%)	18 (30.0)	12 (20.0)	1 (1.7)	2.22	0.136
girls, n (%)	23 (38,3)	6 (10,0)	0 (0)		

A – children aged 5; B – children aged 6; N – neurologically normal; S-MND – simple MND; C-MND – complex MND.

Table 3

Prevalence of various forms of minor neurological dysfunction (MND) in the groups A and B

MND forms	Group A (n = 60) n (%)	Group B (n = 60) n (%)	χ^2	*p*
Severity				
healthy	26 (43.3)	41 (68.3)		
simple	31 (51.7)	18 (30.0)	**6.6**	**0.01**
complex	3 (5.0)	1 (1.7)		
Type				
mild dysfunction in posture and muscle tone	1 (1.7)	0 (0)	NA	NA
mild abnormal reflexes	0 (0)	0 (0)	NA	NA
mild dyskinesia	0 (0)	0 (0)	NA	NA
mild coordination problems	27 (45.0)	11 (18.3)	**8.7**	**0.003**
mild fine manipulative disability	11 (18.3)	5 (8.3)	1.8	0.178
excess of associated movements	11 (18.3)	5 (8.3)	0.2	0.618
mild sensory dysfunction	0 (0)	0 (0)	NA	NA
mild cranial nerve dysfunction	0 (0)	0 (0)	NA	NA

A – children aged 5; B – children aged 6; NA – not available.

In the total sample of participants (120 children), 67 (55.8%) of them had normal neurological results, 49 (40.8%) showed simple MND while 4 (3.4%) showed complex MND. It was found, when the values of MND prevalence of the groups were compared, that there existed a statistical significance (Table 3). According to further analysis of the particular domains, in the domain of coordination and balance, MND occured more frequently in children from the group A at a statistically significant level. However, in other domains, there was no statistical significance observed.

When the sample of children with simple MNDs from the group A (31 children) was analyzed, it showed that 10 of them had a deviation in two domains, and in the group B, only 3 out of 18. The children from both groups with complex MNDs (4 children from the group A and one child from the group B) showed differences in the domains of coordination and balance, fine motor skills and associated movements.

Looking at the entire sample of participants (n = 120, *df* = 1) and comparing the values for boys and girls in the domain of fine motor skills, it was found, at a statistically significant level, that deviations occur in boys more frequently ($\chi^2 = 7.15$; $p = 0.008$). When the values for boys and girls in other domains were compared, there was no statistical significance observed.

Discussion

Neurological condition with respect to MND helps to identify the vulnerability of a child to development of motor impairment, difficulties in learning or behavioral disorders [2]. For this reason, it is extremely important to test children at preschool age, so that we identify the children who are potentially at a risk, begin the adequate therapy in time and reduce the aforementioned problems. Our study showed a high prevalence of MND in a sample of preschool children. MNDs were diagnosed in 44.2% (53 of 120) children who were tested, 40.8% of those who showed the presence of simple MNDs, and 3.4% of those with complex MNDs. Studies of other authors showed the prevalence of 24%–27% in children 6–11 years of age [4, 8]. A higher prevalence of MND in our study could be explained by the age of the respondents as the deviations are more common in younger children, as indicated in studies by other authors [9]. A research conducted in Holland, also showed a significantly higher prevalence of MND in relation to the general population. Namely, when children aged 4 were tested, complex MNDs were present in as many as 25% of children, and such a high prevalence was probably caused by subfertility of the parents as one of the risk factors [10]. Our study showed that there was a statistically significant difference in the prevalence of MNDs with respect to age; the children from the younger group showed a higher prevalence of MND (56.7%) compared to the children from the older group (31.7%). The prevalence of MND in the general population depends both on the age of children and on the possible risk factors (prematurely born neonates, low

birth weight, the use of corticosteroid therapy after birth, artificial nutrition of infants, autism and dyslexia) [6, 11–13]. There were some research about the impact of artificial insemination on the presence of MND in children born in this way compared to naturally conceived children, but they showed that *in vitro* fertilization did not affect the prevalence of MND [14, 15].

The domains of dysfunction with the greatest clinical significance are the domains of fine motor skills and coordination problems and, therefore, it is not surprising that they are most frequently associated with motor disorders, learning disabilities and mental disorders [2, 4, 16]. In our sample, neurological dysfunctions were most frequently present in the domain of coordination (31.7%), associated movements (15.8%) and fine motor skills (13.3%). Deviations in the domain of fine motor skills in the older group were less frequent (8.3%) than in the younger group (18.3%). Similar results were obtained by Stich et al. [9]. In our study, deviations in other domains also prevaled in children of the younger age group, but they were also present in the older group, which can cause difficulties in mastering the school curriculum. Monitoring preschool children is necessary in order to assess and identify MNDs, especially in the older group. This would make it possible to intervene before school in the domain with a more significant deviation, and the ultimate goal is mastering the school curriculum more easily. Also, it is important to test children aged 5 years, because in our country, the oldest groups at the age of 6 years already start preparing for school, focusing on the development of graphomotorics. This would allow early intervention and help specific children prepare for school.

The conducted study showed that MND was more frequent in boys than in girls. Thirty-three children out of 53 (62.3%) children diagnosed with dysfunction were male. Similar results were obtained by Kikkert et al. [7], who examined children aged 9 years, and showed that the deviation occurred more frequently in boys (61%). Researches of other authors also showed a greater prevalence of MND in boys [6]. The explanation of this phenomenon could be sought in the possible differences in development of nervous systems in boys and girls. Numerous studies point to the differences in the structure [17, 18] and functioning of the male and female brain and the cause may be in the differences in the sex hormones as well as genetic differences, namely the presence of Y chromosome in male population carrying certain genes that the genome of a female individual does not have [17, 19, 20]. In the domain of the fine motor skills, there is a statistically significant difference in prevalence with respect to sex – deviations are more common in boys.

The limitations of this study are: longitudinal monitoring of the sample was not done. A possible effect of other factors such as premature birth, gestational age, birth weight, Apgar score, intracranial hemorrhage, etc., were not tested. We did not analyse neuroimaging findings during this study. Also, future research should examine the prevalence of MND regarding social factors, the period of attending kindergarten, as well as sports activities.

Conclusion

Minor neurological dysfunctions are more common in younger children and boys, and the most frequent domains of deviation are coordination and balance, fine motor skills and associated movements. We recommend to test children at the preschool age in order to identify possible deviations and begin with an adequate therapy in time.

REFERENCES

1. *Touwen BC*. Neurological development of the infant. In: *Davis JA*, *Dobbing J*, editors. Scientific Foundations of Paediatrics. 2nd ed. London: Heinemann Medical Books 1981. p. 830–42.
2. *Hadders-Algra M*. Neurological examination of the child with minor neurological dysfunction. London: Mac Keith Press; 2010.
3. *Lunsing RJ, Hadders-Algra M, Huisjes HJ, Touwen BC.* Minor neurological dysfunction from birth to 12 years
4. *Peters LH, Maathuis CG, Hadders-Algra M*. Limited motor performance and minor neurological dysfunction at school age. Acta Paediatr 2011; 100(2): 271–8. PubMed PMID: 20804459
5. *Hadders-Algra M.* The neuromotor examination of the preschool child and its prognostic significance. Ment Retard Dev Disabil Res Rev 2005; 11(3): 180–8.
6. *Arnaud C, Daubisse-Marliac L, White-Koning M, Pierrat V, Larroque B, Grandjean H,* et al. Prevalence and associated factors of minor neuromotor dysfunctions at age 5 years in prematurely born children: The EPIPAGE Study. Arch Pediatr Adolesc Med 2007; 161(11): 1053–61.
7. *Kikkert HK, de Jong C, van den Heuvel ER, Hadders-Algra M*. Minor neurological dysfunction and behaviour in 9-year-old children born at term: Evidence for sex dimorphism. Dev Med Child Neurol 2013; 55(11): 1023–9.
8. *Peters LH, Maathuis CG, Hadders-Algra M.* Children with behavioral problems and motor problems have a worse neurological condition than children with behavioral problems only. Early Hum Dev 2014; 90(12): 803–7.
9. *Stich H, Baune B, Caniato R, Mikolajczyk R, Kramer A*. Individual development of preschool children - prevalences and determinants of delays in Germany: A cross-sectional study in Southern Bavaria. BMC Pediatrics 2012; 12(1): 188.
10. *Bennema AN, Schendelaar P, Seggers J, Haadsma ML, Heineman MJ, Hadders-Algra M.* Predictive value of general movements' quality in low-risk infants for minor neurological dysfunction and behavioural problems at preschool age. Early Hum Dev 2016; 94: 19–24.
11. *Punt M, de Jong MD, de Groot ED, Hadders-Algra M.* Minor neurological dysfunction in children with dyslexia. Dev Med Child Neurol 2010; 52(12): 1127–32.
12. *de Jong M, Punt M, de Groot E, Minderaa RB, Hadders-Algra M.* Minor neurological dysfunction in children with autism spectrum disorder. Dev Med Child Neurol 2011; 53(7): 641–6.
13. *Hsu J, Tsai M, Chu S, Fu R, Chiang M, Hwang F,* et al. Early detection of minor neurodevelopmental dysfunctions at age 6 months in prematurely born neonates. Early Hum. Dev 2013; 89(2): 87–93.

14. *Schendelaar P.* Offspring of subfertile couples: neurodevelopmental outcomes at preschool age. [thesis]. Groningen: University of Groningen; 2015.
15. *Schendelaar P, van den Heuvel ER, Heineman MJ, La Bastide-van Gemert S, Middelburg KJ, Seggers J,* et al. Increased time to pregnancy is associated with less optimal neurological condition in 4-year-old singletons, in vitro fertilization itself is not. Hum Reprod 2014; 29(12): 2773–86.
16. *Kikkert HK, de Jong C, Hadders-Algra M.* Minor neurological dysfunction and cognition in 9-year-olds born at term. Early Hum Dev 2013; 89(5): 263–70.
17. *Loke H, Harley V, Lee J.* Biological factors underlying sex differences in neurological disorders. Int J Biochem Cell Biol 2015; 65: 139–50.
18. *Ruigrok AN, Salimi-Khorshidi G, Lai MC, Baron-Cohen S, Lombardo MV, Tait RJ,* et al. A meta-analysis of sex differences in human brain structure. Neurosci Biobehav Rev 2014; 39: 34–50.
19. *Trabzuni D, Ramasamy A, Imran S, Walker R, Smith C, Weale ME*, et al. Widespread sex differences in gene expression and splicing in the adult human brain. Nat Commun 2013; 4: 2771.
20. *McCarthy MM, Arnold AP, Ball GF, Blaustein JD, de Vries GJ.* Sex differences in the brain: The not so inconvenient truth. J Neurosci 2012; 32(7): 2241–50.

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