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THE FREQUENCY OF DYSCALCULIA AMONG PRIMARY SCHOOL CHILDREN

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SUMMARY

Background: *Formal education, daily living activities and jobs require knowledge and application skills of counting and simple mathematical operations. Problems with mathematics start in primary school and persist till adulthood. This is known as dyscalculia and its prevalence in the school population ranges from 3 to 6.5%.*

Subjects and methods: *The study included 1424 third-grade students (aged 9-10) of all primary schools in the City of Kragujevac, Serbia. Tests in mathematics were given in order to determine their mathematical achievement. 1078 students (538 boys and 540 girls) completed all five tests.*

Results: *The frequency of dyscalculia in the sample was 9.9%. The difference between boys and girls according to the total score on the test was statistically significant ($p<0.005$). The difference between students according to their school achievement (excellent, very good, good, sufficient and insufficient) was statistically significant for all tests ($p<0.0005$). The influence of place of residence/school was significant for all tests ($p<0.0005$). Independent prognostic variables associated with dyscalculia are marks in mathematics and Serbian language.*

Conclusion: *Frequency of dyscalculia of 9.9% in the sample is higher than in the other similar studies. Further research should identify possible causes of such frequency of dyscalculia in order to improve students` mathematical abilities.*

Key words: *mathematics – dyscalculia - prevalence*

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INTRODUCTION

In order to solve everyday problems it is necessary to use many skills that include a set of rules and algorithms (Ramaa et al. 2002). Moreover, formal education, daily living activities and jobs require knowledge and application skills of counting and simple mathematical operations related to addition, subtraction, multiplication and division (Floyd et al. 2003).

Problems with mathematics start in primary school and persist till adulthood (Bojanin 2002). Considering the fact that mathematics is hierarchical, students who did not understand the previous material will, in addition to their problems in basic mathematics, also experience failure that may eventuate to mathematical anxiety (Miller et al. 1997). These combined difficulties appear in the clinical form called dyscalculia which is a set of specific difficulties in learning mathematics and in performing mathematical tasks in children with normal intelligence, access to education and without severe psychological problems (Bojanin 2002, Sharma 2001). Dyscalculia prevalence studies have been performed in many countries using different criteria (Jovanović et al. 2008). According to DSM IV (Shalev 2004) criteria, the incidence of dyscalculia is 1% of the school population. However, studies of dyscalculia in America, Europe and Israel show that the prevalence of developmental dyscalculia in these countries is about 3 to 6.5% (Shalev & Gross-Tsur 2001). An epidemiological study derived on school population in Greece showed that the prevalence of dyscalculia was 6.3% (Koumoula et al. 2004) which coincides with a prevalence of dyscalculia 6.4% among children of school population in Bratislava (Kosc 1974).

Other authors (Lewis et al. 1994) found prevalence of dyscalculia of 1.3% among children aged 9-10 years. The similar results were obtained by Gowaramma (2000). However, Barbaresi (2005) found that cumulative incidence of dyscalculia by age 19 years varying from a low of 5.9% to a high of 13.8% depending on the mathematics learning disorder definition.

So far, a unanimous opinion about the frequency of dyscalculia between genders does not exist. The general opinion is that boys do mathematics better than girls (Ardila et al. 2002). The opinion of teachers is that the sex has no influence on success in mathematics (Koumoula et al. 2004). In many epidemiological studies, the researchers found a higher incidence of mathematical difficulties among boys (Share et al.1988, Badian 1983, Von Aster 2000, Barbaresi et al.2005).

However, most prevalence studies of developmental dyscalculia point to equal rates between the sexes (Shalev et al. 2001, Lewis et al. 1994).

SUBJECTS AND METHODS

The study was conducted from 4 - 9 June 2008 and included 1424 third-grade students (aged 9-10) of 21 primary schools in the City of Kragujevac, Serbia. Before the study started we received permission from the Ministry of Education and approval of all school princepals. Ethic Committee, School of Medicine, Kragujevac also approved this research as a part of PhD theses. Because there is not Serbian validated version of any instrument for dyscalculia, we prepare the set of mathematical tests which covered different mathematical fields. All tests are consistent with the objectives required by the Regulations of the curriculum for the third grade of primary education of Ministry of Education of Serbia. Tests were distributed together by a professional team of teachers. The students who did not complete the entire test were excluded from further processing. At the end of the first part of the study, 1078 students (538 boys and 540 girls) completed all five tests.

Instruments/The set of mathematical tests

The set of mathematical tests consisted of five subtests (each subtest had 10 tasks). The selected tasks were medium difficult and did not include problem-solving tasks. Before the test administration, we conducted a check out of the test processing time, individually, for one school lesson (45 minutes).

Tests were given collectively. The first test (T1) included continuing the number sequence, reading and writing numbers, i.e. 246 (__); Seven hundred twenty three (__); 614 (__); 171 (__); put the numbers from the smallest to the largest for example (the given numbers write in into the appropriate field so that the numbers are arranged from the smallest to the largest 699, 801, 565, 950, 782), the determination of place values of digits in three - digit numbers, oral addition (Calculate: 745+5=__, 546+30=__, 482+174=__), written addition.

The second test (T2) was based mainly on the tasks of subtraction and using of characters-more than or less than or equal, i.e. 843-615=__ or 834-615=__, 492-348=__ or 683-539=__. The numbers are given 334 and 212. Calculate the difference of their sum and difference is Minuend number 45 and subtrahend 798. Calculate the difference and check by addition.

The third test (T3) examined the ability of multiplication and division. Minuend is product of numbers 243 and 4, and subtrahend is product of numbers 124 and 7. What should be calculate? Sum of numbers 689 and 268 divide with 7. What is the rest? 97 • 6 : 2=__; (874-354) : 5=__.

The fourth test (T4) included the use of units of measure such as conversion of small measure to larger, the knowledge of telling the time, converting hours into minutes, converting years into months and vice versa, i.e Fill in the gaps with < or > or = to get correct solution: 45 dm __ 630 cm; 830 mm __ 43 dm; or Calculate: 5 l=__dl; 500 cl=__l; 3h__ 180 min; 5h __ 300 min.

The fifth test (T5) referred to geometric abilities such as drawing circles with common point, identification of the circle and the circumference, identifycation of quadrilaterals (squares and rectangles) in the pictures, "reading the angles", calculating perimeters of the triangles and quadrilaterals; i.e. Calculate perimeter of a triangle with sides a = 2 cm, b = 5 cm and c = 4 cm. Or all pages of the triangle with a perimeter of 24 cm are of equal length. Find sides of the triangle.

Tasks were scored after the tests completion, according to the percentage of solving the task. One point was given for tasks which were solved between 90 and 100%; two points were given for tasks solved by 80to 90% of students; three points for - 70-80%; four points for 60-70%; five points for 50-60%; six points for 40-50%; seven points for 30-40%, eight points for 20-30%; nine points for 10-20% and 10 points for tasks solved by 0-10% of students. Using this scoring we obtained a final score for each test and for total test as well. Also, in this way we got the difficulty balanced tests. The total score in all five tests was 180.

At the first phase of research the diagnosis of dyscalculia was meet if student:
- Attend regular elementary schools;
- Attend the classes regularly;
- Completed all five tests;
- Not have psychiatric disorder and
- Scored below 1.5 SD of average score on the test.

Statistical data processing

The data were analyzed in software statistical package SPSS 17.0. We performed descriptive statistics for the total test and ANOVA to determine inter-group differences. We studied the correlation between marks and test results as well as between student achievements and performance on the tests.

RESULTS

The frequency of the dyscalculia in the sample is 9.9%. Some socio-demographic characteristics of children with dyscalculia and the whole sample are shown in Table 1.

According to all tests results we found that 5% of the pupils have less then or equal 34.13. points; 10% of the pupils have less then or equal 52.65 points; 25% of the pupils have less then or equal 87.33 points and 50% of the pupils have less then or equal 115.70 points (Table 2).

Differences between subtests form subtest T1 to T5 were given in the Table 3. Areas under ROC curve shows that subtests T1, T2, T3, T4 and T5 could be markers for dyscalculia. Subtest T3 related to student's abilities to multiplication and division shows the best sensitivity (Table 4).

As the data show, the ratio between boys and girls is 1.9 : 1. The difference in total score on the test between the sexes is statistically significant (p<0.005) which means that boys are predominant in the sample of children with dyscalculia.

The testing was conducted in schools from all areas (urban, suburban, and rural) and according to our results the difference between them is statisticaly significant for all tests (p<0.0005).

Student achievement/general school success

The analysis of the general success of the whole sample and the children with dyscalculia is shown in the Table 5. The difference between excellent, very good, good, sufficient and insufficient was statistically significant for all tests (p<0.000). In the Table 2 we also can see the differences between those two groups according to the marks in mathematics and Serbian language.

Table 1. Some sociodemografic chacteristics of the total sample and in the sample of children with dyscalculia

	Total sample		The sample of children with dyscalculia	
Gender	N	Mean SD	N	Mean SD
male	538	105.39 ± 39.55	70	33.52 ± 11.29
female	540	114.46 ± 36.79	38	31.31 ± 13.07
Total	1078	119.03 ± 30.07	107	32.76 ± 11.92
Place				
urban	840	113.04 ± 36.658	66	34.51 ± 10.50
suburban	141	96.36 ± 41.29	26	30.93 ± 13.87
rural	97	102.78 ± 44.10	15	28.22 ± 13.31
Total	1078		107	

Table 2. Distribution of students according to total points

Total sample	Points	%
53	34.13	5
107	52.65	10
269	87.33	25
539	115.70	50

Table 4. Subtest T3 related to student's abilities to multiplication and division shows the best sensitivity

	Total sample	The sample of children with dyscalculia
Test 3 < 9.75	906	7
Test 3 ≥ 9.75	65	100

Table 3. Sensitivity and specificity of mathematical subtests in the whole sample of children

Subtest	AUROC	p	Cut-off	Sensitivity (%)	Specificity (%)
T1	0.836	0.021	11	77.1	75.7
T2	0.974	0.007	15	93.5	92.7
T3	0.980	0.004	9.75	93.5	93.3
T4	0.961	0.007	14	91.6	87.4
T5	0.939	0.010	15	86.9	84.8

Table 5. General success/school achivment and marks in mathemathics and Serbian language of the total sample and in the dyscalculia sample

	Total sample			The sample of children with dyscalculia		
	General success	Marks in math	Marks in Serbian	General success	Marks in math	Marks in Serbian language
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Excellent	725 (67.3%)	469 (43.5%)	576 (53.4%)	8 (7.5%)	0 (0%)	3 (2.8%)
Very good	252 (23.4%)	315 (29.2%)	298 (27.6%)	37 (34.6%)	11 (10.3%)	22 (20.5%)
Good	94 (8.7%)	195 (18.1%)	131 (12.2%)	55 (51.4%)	35 (32.7%)	27 (25.2%)
Sufficient	4 (0.4%)	96 (8.9%)	72 (6.68%)	4 (3.7%)	58 (54.2%)	53 (49.6%)
Insufficient	3 (0.3%)	3 (0.3%)	2 (0.2%)	3 (2.8%)	3 (2.8%)	2 (1.9%)
Total	1078 (100.0%)	1078 (100.0%)	1078 (100.0%)	107 (100.0%)	107 (100.0%)	107 (100.0%)

Factors that influence the occurrence of dyscalculia

To test the relationship between gender, place of school, general school success, marks in mathematics, marks in Serbian language, we used logistic regression. Independent prognostic variables for occurrence of dyscalculia are marks in mathematics ($p<0.0005$) and Serbian language ($p=0.013$) (Table 6). Odds ratio of marks in mathematics is 0.321 (0.181-0.570) i.e. the better marks in mathematics for 1 unit decreases risk for dyscalculia around three times. Odds ratio of marks in Serbian language is 0.466 (0.256 -0.849).

Table 6. Factors that influence the occurrence of dyscalculia

Factors	p
Gender	p<0.0050
Place	p<0.0005
General school success	p<0.0005
Marks in math	p<0.0000
Marks in Serbian	p<0.0000

DISCUSSION

There are many ways to define a learning disability in mathematics but one of the standard methods is that the children must score at least 1.5 SD below the normative values on the applied test. By applying this criterion, we discovered that the incidence of dyscalculia in our sample was 9.9%. Using the ICD 10 research criteria, according to which the test results should be below 2 SD or alternatively a low criteria in clinical practice (< 1 SD), our criterion is a compromise solution. Using ICD 10 (< 2SD) criteria, the frequency of dyscalculia approaches 4.5% while the larger portion of children fall between 1.5 and 2 SD, that is 5.4%. The opinions of teachers on children's mathematical achievements has proved to be relatively balanced and can be indicative of which children to expect lower scores. Most researchers classify children with difficulties in learning mathematics by using the cut-off criteria by which children should have 35% of the mean values of the mathematics test, but not less than 2 SD. In order to avoid false positive results, some authors used more stringent criteria that rely on reports of teachers and 3 SD below the mean (Landerl, Bevan et al. 2004).

In our research, we found that girls were better in all tests except the fourth, were there was no significant differences. Among 107 students with low mathematical achievement, 70 were boys and 37 girls (boys to girls ratio was 1.9 : 1). Share came to similar results in his research-the ratio between boys and girls was 1.7 : 1 for children with specific difficulties in mathematics (Share et al. 1988). Also, in epidemiological study conducted in the United States, Badian found a higher incidence of developmental discalculia in boys than in girls 2.2 :1.0 (Badian 1983). (Barbaresi et al. 2005) are found more boys than girls, with male: female relative risk ranging from 1.6 to 2.2 depending on the formula applied. In a sample of 93 children with low mathematical commission, divided into four subgrups, von Aster found a difference in three sub-groups, where were more boys than girls in the ratio 2 : 1 (Von Aster 2000). In an earlier study, von Aster claimed that girls had more difficulty with mathematics because of frequent emotional problems (Von Aster 1994). In a survey conducted in India, researchers found that there were more boys with calculation problems, although their teachers reported that girls achieve less than boys (Gowramma 2000). The findings of epidemiological studies are mixed as far as differences between the sexes are concerned. This finding was unexpected, considering that some isolated problems with learning (dyslexia and ADHD) are more frequent in males and in ratio 3.6 : 1 (Koumoula et al. 2004).

This study confirmed that the students' poor results in mathematics and Serbian language were significantly associated with dyscalculia and that these students had difficulties with learning in general.

In addition, many researchers have found that students with learning disabilities have greater difficulties in mathemathics than their peers with no disabilities. Given that mathematics has its own language that includes special terms, namber syntax and symbols, language skills are very important for mathematics achievement. Students who have problems with reading and writing may have problems with mathematics, too. Reading requirements of textual tasks increase with each year so that many students who have difficulty in reading will have problems in solving the tasks set in words. In addition, the written work in mathematics can be difficult for children with difficulties in handwriting, grammar and writing composition (Wadlington E & Wadlington LP 2008). Heterogenity is evident in the classroom where we find students without disabilities and students with learning difficulties, as well as students with mild mental retardation, all studying together. All of them are forced to participate in maths classes continuously, although they have different abilities for adopting mathematical content. They show different results and require special instructions (Wadlington & Wadlington 2008).

We found differences in frequency of dyscalculia between students from rural, suburban and urban areas. Are rural areas poorer, families larger, teachers less experienced in rural areas; or are there more absenteeism from school between childrenin in rural areas; all are questions we investigate in the second phase of the research when we will test the children individually.

CONCLUSION

Dyscalculia frequency of 9.9% in the sample is higher than in the other studies. New epidemiological studies in school population in Serbia will show whether this relatively high prevalence of dyscalculia is constant.

Further research should also identify possible causes of dyscalculia in order to improve students` mathematical abilities. The earliest diagnosis of disability in mathematics in children could provide them with timely expert help and prevention of school failure occurence with the psychological consequences.

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Conflict of interest : None to declare.

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