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FINE MOTOR SKILLS IN CHILDREN WITH DOWN SYNDROME

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Fine motor skills are very important for children's overall functioning. Their development is necessary for many everyday activities such as dressing, feeding, holding objects, etc. Moreover, fine motor skills are also correlated to the childrens' academic success at school. Recent research suggests a close relationship between motor skills and intelligence. Given the relative paucity of literature on fine motor skills in different etiological groups of children with intellectual disability (ID), we examined these skills in children with Down syndrome. The sample for this study comprised 90 children with ID, aged 7-15, who were divided in three etiological groups: 1. Down syndrome, 2. Organic/other genetic cause of ID and 3. Unknown etiology of ID. Fine motor skills were assessed by the Purdue Pegboard Test. The results of this study indicate that children with Down syndrome did not differ statistically significantly from the other two etiological groups. On the other hand, children with unknown etiology of ID performed statistically better than children with organic/other genetic cause of ID. An additional goal was to examine fine motor skills in children with Down syndrome in relation to the child's sex. There were no statistically significant differences in fine motor skills between girls and boys with Down syndrome. It is important to provide children with Down syndrome, and all other children with ID, with early (re)habilitation programs for the improvement of their fine motor skills. Special educators and rehabilitators should play a crucial role in the assessment and in creating programs for the development of these skills.

Key words: *Down syndrome, fine motor skills, intellectual disability, Purdue Pegboard Test*

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INTRODUCTION

Fine motor skills are of crucial importance for children's everyday functioning. They are necessary for a number of self-care activities such as dressing, feeding, bathing, holding objects, cutting etc. Besides this, fine motor skills are related to cognitive, social and academic abilities in young children (De Luca et al., 2013). Furthermore, motor functions significantly predict social and emotional adjustment of children to school (Bart et al., 2007). A large study conducted by Gligorović et al. (2011) clearly indicated that motor abilities are significantly correlated with the prerequisites of academic skills. Development of psychomotor abilities of upper extremities is in direct correlation with psychosocial development of personality (Ćordić & Bojanin, 1997). Motor development is dependent on the maturation of the Central Nervous System (CNS) and subsequent maturation of the CNS happens through its myelination (Piper et al., 1994). Most children go through motor development in a predictable manner, although the age of achieving motor milestones might differ among children. Much is known about early child's motor development. There are two main principles of this development: cephalous- caudal and proximal-distal. According to the widely accepted proximal- distal principle, development of trunk stability and central axis control is one of the main prerequisites for hand usage (Case-Smith et al., 1989). Simply put, it means that development of fine motor skills is dependent upon development of gross motor skills which are developed first. At birth, children have very little control over their movements, and primitive reflexes dominate almost all the movements. Later in development, these reflexes disappear and are replaced by sophisticated intentional movements controlled by the brain. In typically developing children these voluntary movements happen between 4 and 6 months of age. By the end of the first year of life, children should be able to pinch and hold little objects between their fingers just like the adults. Fine motor skills can be defined as the coordination of muscles, bones and nerves to produce small precise movements (Kimmel & Ratliff-Schaub, 2011). Due to its importance, there has recently been an increased interest in research on the subject of fine motor skills in children with developmental and intellectual disabilities and creating subsequent (re) habilitation programs. This interest has especially been noted in research on autism spectrum disorder in order to better define early intervention programs (Lloyd et al., 2013). A study by Wuang et al. (2008) found a high prevalence of sensorimotor dysfunctions in children with mild intellectual disability. These authors also found that in children with intellectual disability, fine motor skills are more impaired than gross motor skills.

We wanted to expand this field of research by comparing fine motor skills of children with Down syndrome to children with intellectual disability caused by other factors. Down syndrome is the most common genetic cause of intellectual disability with the prevalence of 1:600 (Davis, 2008). It is a neurogenetic disorder that is affecting growth, development and social participation through a lifespan. It is caused by the presence of a full third copy of chromosome 21 or a part of it. There are three chromosomal forms of the syndrome: trisomy, translocation and mosaicism. In trisomy, each cell contains an extra chromosome 21. In translocation, a part of chromosome 21 is physically attached to another chromosome and in mosaicism only some cells have an extra chromosome, while the other cells are normal. Of all these three forms, trisomy is the most frequent with more than 90% of Down syndrome cases. Presence of the extra copy of chromosome 21 causes a well-defined phenotype of Down syndrome including characteristic facial and musculoskeletal features and increases the risk for additional health problems (Silverman, 2007). People with Down syndrome have frequent hearing and visual difficulties as well as congenital heart disease. In fact, almost 50% of new born children with Down syndrome have congenital heart disease (Baroff & Olley, 2014). Other health problems that people with Down syndrome are prone to are obesity and Alzheimer disease.

Research has shown that children with Down syndrome have a peculiar neuropsychological profile characterized by strengths and weaknesses in certain areas. Thus, children with Down syndrome have deficits in language area, verbal short-term memory and executive functions (Fidler, 2005, Vicari et al., 2004). The areas in which children with Down syndrome reportedly have relative strengths are visual perception and visual motor skills (Fidler & Nadel, 2007). Besides visual perception, these relative strengths also involve implicit memory, which in turn can, together with visual perception, affect the reading skills, especially word identification. These can only be called relative strengths as there are many studies indicating motor impairment in children with DS, both in fine motor and gross motor skills. Also worthy of note is that fine motor skills are more impaired and showing slower developmental progress (Spano et al., 1999). Here it is important to point out that Spano et al. found progress in all aspects of motor skills through development.

The goal of the current study was to examine fine motor skills in children with Down syndrome. In particular, we wanted to assess whether children with Down syndrome are more susceptible to deficits in fine motor skills compared to children with ID of other etiologies. In addition to this goal, we compared motor skills in children with Down syndrome in relation to the child's sex.

METHOD

Participants

The sample for this study comprised 30 children with Down syndrome (15 boys and 15 girls) aged 7-15 years (M= 11.8 years, SD= 2.8 years). There were two control groups of children with intellectual disability in this study. The first control group consisted of 30 children (20 boys and 10 girls) of various genetic and organic etiologies other than Down syndrome (2 children with Williams syndrome, 12 children with Fragile X syndrome, 2 children with Prader Willi syndrome and 14 children with organic causes-brain injury) further referred as children with organic/other genetic cause of intellectual disability. The children in this group were between 7-15 years old (M= 10.6 years, SD= 2.7 years). The second control group also consisted of 30 children (19 boys, 11 girls) of unknown etiology of intellectual disability. The children were between 7-15 years old (M= 11.5 years, SD= 2.6 years). There were no statistically significant differences in the mean age of children in all three groups (F(2)=1.5, p=0.23). Children in this sample were categorized as children with mild or moderate intellectual disability. The proportion of children with mild and moderate ID was not equally distributed across the etiological groups (X^2 (2. 90) = 7.5, p<.05). The proportion of boys and girls in the etiological groups was equally distributed (X^2 (2. 90) = 1.9, p>.05). Distribution of children in relation to the level of ID, gender and etiology is shown in Table 1.

The children in this sample were conveniently selected as we wanted to have the same number of children in each etiologic category. Children in this sample attended two special education centers in Sarajevo, BiH. The same sample of children participated in the study on executive functions of children with intellectual disability and on predictors of visual motor integration (Memisevic & Sinanovic, 2013a, 2013b).

Table 1 – Cross-tabulation of number of children in relation to level of intellectual disability, gender and etiology

Etiology	Mild ID n	Moderate ID n	Boys	Girls
Down syndrome	12	18	15	15
Organic/Other genetic etiology	10	20	20	10
Unknown etiology	20	10	19	11

Instrument and procedure

For the assessment of fine motor speed we used Purdue Pegboard Test (Tiffin, 1968). The test is often used for measuring fine motor dexterity as it has good psychometric properties. According to Tiffin, test-retest reliability ranged between 0.82-0.91. The Purdue Pegboard Test is a board with two sets of 25 holes positioned vertically. The test consists of 4 tasks. The first three tasks require the children to put as many pegs as possible in the 25 holes in 30 seconds, first with the dominant hand, then the non-dominant hand and lastly with both hands. The fourth task involves alternating both hands in order to make as many assemblies as possible within one minute. For the purposes of this study we used only the first task and that is the number of pegs placed in the time frame of 30 seconds with the dominant hand. Purdue Pegboard test was administered to children individually in a typical classroom. Time to complete the individual test was less than 5 minutes including the practice trials. All children understood what was asked of them and were able to perform the task.

Statistical analysis

Descriptive data were presented for the Purdue Pegboard Test for all children. Analysis of Variance (ANOVA) was used to compare the scores between different etiological groups. Significant ANOVA was followed by Tukey post hoc test to determine which groups differ in a statistically significant manner. For the comparison of motor skills in relation to the child's sex, we used an independent t-test, and as a measure of an effect size, we calculated a Cohen's d. An Alpha level of 0.05 was used for all statistical tests. Data were analyzed with a computer program SPSS v.13 for Windows.

RESULTS

In Table 2 we presented descriptive results on Purdue Pegboard test for all children along with the Analysis of Variance results. As can be seen from Table 2, children with unknown etiology achieved the best results on the Purdue Pegboard test, followed by children with Down syndrome and children with other genetic/organic cause of intellectual disability. However, there were no statistically significant differences between the groups according to ANOVA and Tukey post hoc test was not performed.

Table 2 – Descriptive results on Purdue Pegboard test

Etiology	Purdue Pegboard		ANOVA	
			F (2, 87)	ή^2
	M	SD		
Down syndrome	6.3	2.2	7.0*	0.14
Organic/Genetic cause	5.2	2.2		
Unknown etiology	7.5	2.7		

Note. ή^2= effect size. *p<0.01

As can be seen from Table 2, children with unknown etiology of intellectual disability outperformed children with Down syndrome who, in turn, outperformed children with organic/genetic cause of ID. These results were highly statistically significant, so we performed a Tukey post hoc test to determine which groups differ between one another. The results of the Tukey post hoc test are shown in Table 3.

Table 3 – Tukey post hoc test for Purdue Pegboard test

Etiology	N	Subset	
		1*	2**
Down syndrome	30	6.3	6.3
Organic/ other genetic cause	30	5.2	
Unknown cause	30		7.5

Note. *p=0.19; **p=0.12
a. Uses Harmonic Mean Sample Size = 30.0.
b. Alpha = 0.05.

As can be concluded from Table 3, the groups that differ significantly are unknown etiology and other genetic/organic etiology (mean difference 2.3, p<.01). Children with Down syndrome did not statistically differ on Pegboard Purdue test from two other etiological groups.

Finally, we assessed the fine motor skills differences between boys and girls in the sample of children with Down syndrome. We performed an independent t-test (tha data followed normal distribution, Shapiro Wilk test p=.24). The mean results, t value, p value and effect size Cohen's d are shown in Table 4.

Table 4 – Differences on Purdue Pegboard Test between girls and boys with Down syndrome

Children with Down syndrome	Purdue Pegboard Test		t test	Cohen's d
	M	SD		
Boys	6.1	1.94	-0.49*	0.18
Girls	6.5	2.5		

Note. *p=0.63.

From Table 4, we can see that there were no statistically significant differences between boys and girls with Down syndrome on the Purdue Pegboard Test.

DISCUSSION

This study examined fine motor skills in children with Down syndrome compared with two other etiologically different groups of children with intellectual disability, namely children with organic/other genetic cause and unknown cause of intellectual disability. Children with Down syndrome achieved better results than children with organic/other genetic cause of ID, and poorer results than children with unknown etiology. However, these differences on Purdue Pegboard test, between children with Down syndrome and the other two groups were not statistically significant. Statistically significant differences were observed between children with unknown etiology and children with organic/other genetic cause of intellectual disability, where children with unknown etiology achieved better results. Many studies have shown that children with Down syndrome have a heterogeneous cognitive profile (Wang, 1996). The results of this study indicate that having a Down syndrome is not by itself a risk factor for having a fine motor deficit, as compared to the intellectual disability caused by other factors. Some support for this claim may come from the study of Jenni et al., (2013) in which the authors found that motor and intellectual domains of functioning in healthy children are largely independent. On the other hand, there are numerous other studies linking IQ and motor skills (Wuang et al., 2008). It seems that data in this area are still inconclusive, so the findings of this study need to be replicated in a larger and more heterogeneous sample of children with intellectual disability.

In relation to the effects of child's sex on motor performance, although girls with Down syndrome achieved somewhat better results than boys with Down syndrome, these differences were not statistically significant and the subsequent effect size Cohen's d was small. Previous studies on the effect of sex on performance in children with Down syndrome do not lead to a firm conclusion. A study by Dolva et al., (2004) found that girls were better in some areas such as self-care skills, and that boys achieved better results on the mobility domain. It might be that the small sample in our study contributed to findings being non-significant statistically and that in larger samples the differences would be significant. Definitely more studies are needed to further elucidate the effect of sex on the development of children with Down syndrome.

Children with intellectual disability, including children with Down syndrome, are at risk of having fine motor skills delays compared to typically developing children. In this regard it is important to note that fine motor skills can be significantly improved through (re)habilitation. It is encouraging that motor skills can be enhanced, even in children with severe intellectual disability (Pizzamiglio et al., 2008). The role of special educators/ rehabilitators is very important in this process. Their role is multilayered and consists of 1.assessment of fine motor skills, 2.creation of Individual Rehabilitation Plan, 3. implementation of the plan/therapeutic intervention, and 4. evaluation of the intervention. As with any other rehabilitation service, same rules should be applied in improving the motor skills of children with Down syndrome. The remediation intervention needs to start as early as possible to prevent or to reduce future problems. Special educators/rehabilitators are responsible for the whole process and need to follow children at risk starting from the earliest age through kindergarten and school years. Only by this systematic intervention the gap in motor skills between children with ID and typically developing children can be reduced. These (re)habilitation programs are extremely important as the improvement of motor skills leads to the improvement of the quality of life. More emphasis is now being given to independent life of people with Down syndrome with adequate supports.

At the end, let us mention some of the limitations of this study. Fine motor skills are a much broader concept than the one captured by the Purdue Pegboard Test. In this study Purdue Pegboard test was used as a proxy for one of the segments of fine motor skills. Future studies should include a more comprehensive battery of tests as well as reports from everyday functioning to fully evaluate potential deficits of children with Down syndrome in fine motor skills. Also, this study did not use an IQ score as a covariate, which would be beneficial in determining the exact role of and relationship between IQ and fine motor functioning. Finally the sample was conveniently chosen, which may prevent generalization of these findings to all children with Down syndrome.

CONCLUSION

Children with intellectual disability including children with Down syndrome have deficits in fine motor skills. Children with Down syndrome did not differ statistically significantly from children with intellectual disability of other etiology. Boys and girls with Down syndrome did not differ significantly in their fine motor skills. Through the therapeutic intervention of special educators/rehabilitators, these skills can be substanstially improved. Improvement in fine motor skills contributes to better overall functional skills and to the better quality of life. The intervention programs for the improvement of fine motor skills should start as early as possible.

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FINE MOTORIČKE SPOSOBNOSTI KOD DECE SA DAUNOVIM SINDROMOM

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Sažetak

Fine motoričke sposobnosti su veoma važne za celokupno funkcionisanje deteta. Njihov razvoj je važan za mnoge aktivnosti svakodnevnog života kao što su: odevanje,hranjenje, držanje predmeta itd. Pored ovoga, fine motoričke sposobnosti su povezane sa dečijim uspehom u školi. Novija istraživanja pokazuju vezu između motoričkih sposobnosti i inteligencije. S obzirom na relativnu oskudnost literature o karakteristikama finih motoričkih sposobnosti dece sa intelektualnom ometenošću različite etiologije, u ovom radu smo ispitali fine motoričke sposobnosti kod dece sa Daunovim sindromom. Uzorak za ovo istraživanje činilo je 90 dece sa intelektualnom ometenošću, u dobi od 7-15 godina, koja su podeljena u grupe prema kriterijumu etiologije intelektualne ometenosti: 1. Daunov sindrom, 2. Organski/drugi genetički uzrok intelektualne ometenosti i 3. Nepoznata etiologija. Nivo razvijenosti fine motorike je ispitan Purdue Pegboard testom.

Rezultati ove studije pokazuju da se deca sa Daunovim sindromom statistički značajno ne razlikuju od druge dve grupe dece. S druge strane, deca sa nepoznatom etiologijom intelektualne ometenosti postigla su statistički značajno bolji rezultat od dece sa organskom/ drugi genetički uzrok etiologijom intelektualne ometenosti. Nisu nađene statistički značajne razlike između dečaka i devojčica sa Daunovim sindromom na testu fine motorike. Važno je deci sa Daunovim sindromom obezbediti (re)habilitacijske programe za poboljšanje fine motorike u periodu rane intervencije. Specijalni edukatori i rehabilitatori (defektolozi) trebalo bi da igraju ključnu ulogu u proceni i u kreiranju programa za razvoj ovih veština.

Ključne reči: Daunov sindrom, fine motoričke sposobnosti, intelektualna ometenost, Purdue Pegboard Test

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