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Evaluation of the Intellectual Skill Problems of Hydrocephalic Children: A Clinical Study

Hidrosefalisi Olan Çocukların Entellektüel Beceri Problemlerinin Değerlendirilmesi: Bir Klinik Çalışma

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ABSTRACT

AIM: This study is plained to determine the intellectual skill difficulties and attention problems of hydrocephalic children, and to compare them to children with attention deficit hyperactivity disorder (ADHD).

MATERIAL and METHODS: The Wechsler Intelligence Scale for Children-Revised (WISC-R) test was applied to healthy children (control group), hydrocephalic children (hydrocephalus group) and children with ADHD (ADHD group); and the test results were statistically analyzed with the Multivariate Analysis of Variance (MANOVA) and linear logistic regression test.

RESULTS: All test results of the hydrocephalus group were significantly worse than the ADHD and control groups. However, the ADHD group showed performances as good as the control group at the tests except for the arithmetic, digit span, block design, object assembly and coding subtests.

CONCLUSION: The WISC-R results suggested that the ADHD group has more difficulties with their encode, focused/execute attention and sustain attention than visual attention. However, children with hydrocephalus have much more problems with their visuospatial perception, material organization and attention (especially encode, focused/execute attention and sustain attention); and these problems could produce adaptive problems in their social, cultural, behavioral and academic achievement.

KEYWORDS: Attention, ADHD, Hydrocephalus, WISC-R

ÖZ

AMAÇ: Bu çalışma, hidrosefalisi olan bir grup çocuğun biliş ve dikkat alanlarındaki bozulmalarını belirlemeye yönelik olarak planlanmıştır. Ayrıca çalışmada, bu alanlardaki sorunlarda dikkat eksikliği/hiperaktivite bozukluğu (DEHB) olan çocuklara göre etkilenmenin düzeyini tespit etmek de amaçlanmıştır.

YÖNTEM ve GEREÇ: Çalışma örneklemi Hidrosefali, DEHB ve sağlıklı çocuklardan oluşan Kontrol grubundan oluşturulmuş ve her üç gruba da Wechsler Intelligence Scale for Children-Revised (WISC-R) testi uygulanmıştır. Test sonuçları Çok Değişkenli Varyans Analizi (MANOVA) ve lineer lojistik regresyon analizi testleri uygulanarak karşılaştırmalı analiz edilmiştir.

BULGULAR: Hidrosefali grubundaki çocuklar WISC-R ve bunun tüm altteslerinde DEHB ve Kontrol grubundaki çocuklara göre belirgin düzeyde başarısız bulunmuştur. Oysa DEHB grubundaki çocuklar Aritmetik, Sayı Dizileri, Küplerle Desen, Parça Birleştirme ve Şifre Alttestleri hariç kontrol grubundaki çocuklarla benzer başarı sergilemişlerdir.

SONUÇ: WISC-R test sonuçları göstermiştir ki DEHB grubu çocuklar dikkati oluşturma, sürdürme ve kaydırmada sorunlar yaşarken; hidrosefalisi olan çocuklar bunlara ilave görsel dikkat, üç boyutlu algı ve düşünme ve sözel zeka alanlarında da belirgin problemler yaşamakta ve bu problemler bu çocukların sosyal, kültürel, davranışsal ve akademik başarılarını doğrudan etkiler görünmektedir.

ANAHTAR SÖZCÜKLER: DEHB, Dikkat, Hidrosefali, WISC-R

INTRODUCTION

The long term intellectual prognosis of non-tumoral hydrocephalus patients show a full intellectual quotient (IQ) greater than 70, but they often have different quotients for verbal and performance test results because of poor visuospatial skills. They have much more difficulty with non-verbal skills than verbal ones and sex, age, delay before shunting and frequency of shunt complications (ie. multiple applications) are not related to the IQ level or its pattern (1,5,9).

On the other hand, Burmeister et al. (2005) suggested that children with hydrocephalus have a higher rate of attention deficit (31%) than seen in normal population (17%). This attention deficit seems to be similar to the inattentive type of attention deficit hyperactivity disorders (ADHD) as demonstrated by difficulties with distractibility, organizing and staying on task. They also speculated that these patients have specific behavioral characteristics including excessive and often inappropriate sociability, excessive verbosity, and other examples of poor social skills. It could also lead to the development of behavioral problems such as nonverbal learning disabilities. These difficulties are related to the hydrocephalus directly and not the hyperactivity or impulsivity (3,5).

There has been some recent research comparing hydrocephalus with ADHD, but there are no studies comparing them with the Wechsler Intelligence Scale for Children-Revised (WISC-R) which measures the IQ and its subunits (2,3). The primary purpose of this prospective study was to describe neuropsychological problems, other intellectual skill difficulties and attention of children with shunted hydrocephalus. The secondary purpose of this study was to determine the similarities and differences of attention problems in hydrocephalic children and children with ADHD.

MATERIALS and METHODS

Subjects

The research group contained healthy children (named the control group), children with ADHD (named the ADHD group) and children with hydrocephalus (named the hydrocephalus group).

The hydrocephalus group (n: 26) consisted of children aged 6-16 (73-192 months) years followed up at the Hacettepe University Faculty of Medicine, Department of Neurosurgery with shunted hydrocephalus and who had not undergone shunt revision in the last two years. The hydrocephalus group subjects were chosen from children with no motor and sensorineural deficit and subjects with other neurological abnormalities such as tumor, intraventricular hemorrhage or stroke were excluded. This group could be divided into two subgroups etiologically as follows: patients with low level spina bifida (n: 10) and patients with triventricular hydrocephalus (n: 16). All subjects were statistically analysed to determine the effect of the etiological factors described above on the WISC-R points used by MANOVA and there was no statistically significant difference between them, and this group was therefore not divided into its subgroups.

The ADHD group (n: 26) consisted of subjects aged 6-16 (82-156 months) years who were diagnosed as inattentive type-ADHD at the Hacettepe University, Ihsan Dogramaci Children Hospital, Department of Child Psychiatry; and had not been started on drug therapy.

The control group consisted of 26 healthy children aged 6-16 (91-160 months) years.

Table I presents the sex and age information for all the groups (Table I).

Test Materials

WISC-R was performed on all groups using routine procedures. This test is divided into three subtests which contains Verbal, Performance and Total IQ scales. The verbal tests consist of Information, Similarities, Arithmetic, Digit Span, Comprehension and Vocabulary subtests. The performance tests contains Picture Completed, Picture Arrangement, Block Design, Object Assembly, Coding and Labyrinth subtests. The Vocabulary and Labyrinth subtests were not performed. Total IQ points were calculated by adding the verbal and performance test points (15, 16).

The WISC-R was standardized for Turkish children by Savasir and Sahin in 1982 (12).

Statistical Analysis

The Verbal, Performance and Total IQ points for the ADHD, hydrocephalus and control groups were analysed by the Multivariate Analysis of Variance (MANOVA); and p values less than 0.05 were considered to be significant. The linear logistic

Table I: Descriptive table of the demographic data of the all groups.

GROUP	Sex	n	Min (month)	Max. (month)	Mean (month)	Std. Dev.
Hydrocephalus	**Female**	14	77.00	183.00	122.50	31.06
	Male	12	73.00	192.00	128.27	36.05
ADHD	**Female**	15	93.00	156.00	121.60	25.39
	Male	11	82.00	156.00	129.09	24.67
Control	**Female**	15	91.00	160.00	123.46	23.84
	Male	11	92.00	147.00	124.36	21.89

regression analysis was performed to all WISC-R points to determine the subtest which significantly demonstrated the differences between the hydrocephalus, ADHD and control groups; and p values less than 0.05 were considered to be significant (10,13).

RESULTS

Table II shows the mean values of WISC-R points of all groups (Table II). These values were analysed by MANOVA and there were statistically significant differences between all groups (Wilks lambda 0.90, p=0.024). The results showed that the hydrocephalus group had lower points than the ADHD and control groups.

To determine the statistical differences within all groups, performance points for each subtest were analysed by MANOVA, and the results showed that the hydrocephalus group had much more difficulty with both verbal and non-verbal skills than the ADHD and control groups ($p< 0.001$); and their Verbal IQ, Performance IQ and Total IQ points were also worse than the ADHD and control groups (Table III, Figure 1). Their Performance IQ points were found to be significantly worse than the Verbal IQ

Table II: Means of the WISC-R points showing that children with hydrocephalus have worse intellectual quotients than the ADHD and control groups, *MANOVA test; Wilks lambda 0.90, p=0.024.*

WISC-R Points	Hydrocephalus	ADHD	Control
Verbal Subtest Points			
Information	7.04±2.77	9.15±2.68	10.19±1.72
Similarities	9.11±3.06	11.19±2.13	12.11±1.94
Arithmetic	8.04±2.89	9.42±2.06	12.00±2.13
Comprehension	8.15±2.20	10.96±2.22	11.38±2.64
Dijit Span	7.61±3.65	8.85±2.22	11.61±2.67
Performance Subtest Points			
Picture Completed	6.81±2.84	11.38±2.45	12.61±1.74
Picture Arragement	6.77±2.80	9.54±2.80	11.19±2.83
Block Design	8.00±3.25	10.58±2.65	12.92±2.46
Object Assembly	6.92±2.53	10.65±3.17	13.57±1.79
Coding	7.15±3.47	9.65±2.41	11.96±2.44
Total IQ			
Verbal IQ	86.88±16.00	100.00±11.12	109.84±9.03
Performance IQ	80.04±18.22	102.61±12.76	118.27±11.55
Total IQ	82.15±15.18	101.23±11.36	114.92±9.59

Table III: Statistical analysis results demonstrating that in contrast to ADHD and control groups, hydrocephalic children are unsuccessful at all verbal and nonverbal subtests; *MANOVA test; p<0.05.*

Verbal subtest	Group		Sig.	Performance subtest	Group		Sig.
INFORMATION	Hydrocephalus	Control	.000	PICTURE COMPLETION	Hydrocephalus	Control	.000
		DEHB	.007			DEHB	.000
	Control	Hydroce	.000		Control	Hydroce	.000
		DEHB	.281			DEHB	.158
	DEHB	Hydroce	.007		DEHB	Hydroce	.000
		Control	.281			Control	.158
SIMILARITIES	Hydrocephalus	Control	.000	PICTURE ARRANGEMENT	Hydrocephalus	Control	.000
		DEHB	.008			DEHB	.002
	Control	Hydroce	.000		Control	Hydroce	.000
		DEHB	.362			DEHB	.093
	DEHB	Hydroce	.008		DEHB	Hydroce	.002
		Control	.362			Control	.093
ARITHMETIC	Hydrocephalus	Control	.000	BLOCK DESIGN	Hydrocephalus	Control	.000
		DEHB	.099			DEHB	.004
	Control	Hydroce	.000		Control	Hydroce	.000
		DEHB	.001			DEHB	.010
	DEHB	Hydroce	.099		DEHB	Hydroce	.004
		Control	.001			Control	.010
COMPREHENSION	Hydrocephalus	Control	.000	OBJECT ASSEMBLY	Hydrocephalus	Control	.000
		DEHB	.000			DEHB	.000
	Control	Hydroce	.000		Control	Hydroce	.000
		DEHB	.795			DEHB	.000
	DEHB	Hydroce	.000		DEHB	Hydroce	.000
		Control	.795			Control	.000
DIGIT SPAN	Hydrocephalus	Control	.000	CODING	Hydrocephalus	Control	.000
		DEHB	.285			DEHB	.006
	Control	Hydroce	.000		Control	Hydroce	.000
		DEHB	.003			DEHB	.012
	DEHB	Hydroce	.285		DEHB	Hydroce	.006
		Control	.003			Control	.012

points statistically (p<0.05). The localization of shunt catheters, age, sex or etiological factors did not affect the WISC-R test results (p> 0.05) (Figure 1).

The ADHD group had difficulties at the verbal and performance test, but their verbal test skills were as well as control group except their Arithmetic and Digit Span subtests (p< 0.05). The ADHD group also had problems at some performance subtests, especially with Block Design, Object Assembly and Coding (p< 0.001); but their Picture Completed and Picture Arrangement points were as good as the control group (p> 0.05) (Table III). Their Total IQ levels were lower than the control group but better than hydrocephalus group. As expectedö the ADHD group showed better performance at the WISC-R subtests and especially at the verbal skills than the hydrocephalus group (Table IV, Figure 1).

The linear logistic regression analysis was performed for WISC-R points to determine to which subtest significantly measured the differences between ADHD and hydrocephalus; and the results showed that Picture Arrangement subtest explained the differences significantly (p< 0.001). This subtest specifically measured the significance between ADHD and hydrocephalus as 80.77% (Table VI). Linear logistic regression analysis was also applied

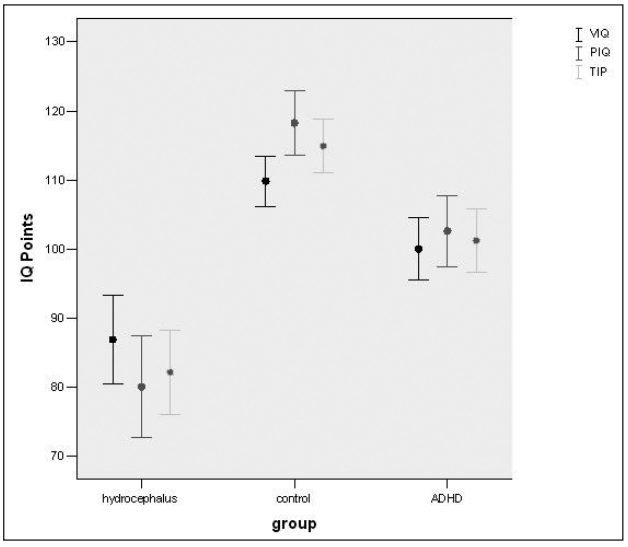

Figure 1: *Figure showing the mean values of the Verbal, Performance and Total IQ points. Each error bar shows the minimum and maximum of the IQ values (VIQ: Verbal IQ points; PIQ: Performance IQ Points; TIQ: Total IQ Points).*

Table IV: Statistical analysis results showing that hydrocephalic children have low points at verbal, performance and total IQ tests; *MANOVA test; p<0.05.*

IQ	Group		Sig.
VERBAL IQ	Hydrocephalus	Control	.000
		ADHD	.001
	Control	Hydrocephalus	.000
		ADHD	.015
	ADHD	Hydrocephalus	.001
		Control	.015
PERFORMANCE IQ	Hydrocephalus	Control	.000
		ADHD	.000
	Control	Hydrocephalus	.000
		ADHD	.001
	ADHD	Hydrocephalus	.000
		Control	.001
TOTAL IQ	Hydrocephalus	Control	.000
		ADHD	.000
	Control	Hydrocephalus	.000
		ADHD	.000
	ADHD	Hydrocephalus	.000
		Control	.000

to the WISC-R points of the hydrocephalus and control groups and it showed that the Arithmetic and Object Assembly subtests specifically measured the differences within them as 80.77% (p< 0.001) (Table VII).

Table V: Table showing the subtypes of the attention according to Mirsky et al (1991).

Attention type	Description
Focus/execute	Capacity to concentrate attentional resources on a specific task
Sustained attention	Ability to stay in task in a vigilant manner
Stability	Capacity to maintain a regular, predictive response rhythm to task stimuli over time
Shifting attention	Ability to shift attentional focus from one aspect of a stimuli to another
Encode	Capacity to hold information briefly in mind while performing some action or cognitive action on it

Table VI: Table showing that the Picture Arrangement subtest measures the significant differences between ADHD and hydrocephalus by 80.77% specifically; *Linear Logistic Regression Analysis test*

	Predicted Group		
Analyzed Group	**ADHD**	**Hydrocephalus**	**Correct Discrimination**
Hydrocephalus (n= 26)	21	5	80.77%
ADHD (n= 26)	5	21	80.77%
Sum	**26**	**26**	**80.77%**

Table VII: Table showing that Arithmetic and Object Assembly subtests measure the differences within Hydrocephalus and control groups by 80.77% specifically; *Linear Logistic Regression Analysis test.*

	Predicted Group		
Analyzed Group	**Control**	**Hydrocephalus**	**Correct Discrimination**
Hydrocephalus (n= 26)	21	5	80.77%
Control (n= 26)	5	21	80.77%
Sum	**26**	**26**	**80.77%**

DISCUSSION

Fletcher et al. (1992) showed that the hydrocephalic children have low points at their performance tests which measure the functions of the right hemisphere of the brain (known as the non-dominant hemisphere). They also had low performances at their verbal tests which measure functions of the left hemisphere (known as the dominant hemisphere) (4). This study supports this point by its results showing that these children have a much higher prevalence of disturbances of their

visuospatial performance, material organization and attention than disturbances of verbal skills.

The attention skills of ADHD patients are dependant on the role of the anterior and superior frontal regions and basal ganglia which are known as anterior brain attention system. The anterior system is related to the sustaining and maintenance functions of attention (2,3,8,11). However the attention problems of the hydrocephalic children derive from the posterior brain attention system which consist of the pulvinar and parietal cortex. The posterior system mediates attention functions related to focusing and shifting (2,3). Mirsky divided attention into five components: Encode, sustain, focus/executive, shift and stabilize (Table V) (8). The focus and shift attention are significantly destroyed in hydrocephalic children compared to siblings, and the children with ADHD display the expected performance pattern on measures of focused/execute attention but have difficulties with shifting and sustaining attention (2). This study results showed that the ADHD and hydrocephalus groups had problems with their visuospatial performance, visual perceptual organization and three dimensional thinking which is measured by the Object Assembly subtest. They also had poor scores at the Coding subtest which measures the focused/execute attention and sustained attention. These subtests measure the functions of the non-dominant hemisphere of the brain. On the other hand, ADHD and hydrocephalus groups had low performance levels at the Arithmetic (which measures the avoiding of breaking up of the attention, and condensation of the attention; i.e. focus/execute attention), and Digit Span subtests which measure sustained and encode attention. These results suggest that WISC-R test could also measure the attention deficits of the dominant hemisphere of the brain. The linear logistic regression analysis results also showed significant measured differences between hydrocephalus, ADHD and control groups for the WISC-R subtests which are Arithmetic, Picture Arrangement and Object Assembly (80.77%).

Other articles on the visual and verbal test results of hydrocephalic children state that those patients have difficulties with both verbal and visual attention (6,7,17). Our study showed that the hydrocephalic children had poor performances at all the subtests of the WISC-R. The hydocephalus group also had difficulties with their visuomotor and rotation skills, nonverbal and analytic thought which are measured by the *Block Design subtest* like the ADHD group, Unlike the ADHD group, hydrocephalic children also showed low performance at the *Picture Completed* and *Picture Arrangement* subtests which describe visual perceptual organization and three dimensional thinking. In addition, their total IQ points were also worse than the ADHD and control groups. These results point out that they have more difficulties with their attention and other neuropsychological skills than the ADHD group, especially for visuospatial attention which is measured by the performance subtest. These results also suggest that the ADHD group has more difficulties with their encode, sustain and focused/execute attention than visual attention as determined by the *Block Design, Object Assembly, Coding, Arithmetic and Digit Span subtests.*

The statistical analyses performed on demographic data show that the etiology of the hydrocephalus, age, sex and localization of the shunt (frontal or posterior parietal) did not affect the test results, as reported in the literature (1); it could therefore be said that these difficulties may be caused by hydrocephalus itself and not the etiological factors.

There are several limitations of the present study. Although this prospective study has no neuropsychological evaluation of hydrocephalic children preopertively, it can demonstrate that these children have serious problems on their neuropsychological performances behind neurological deficits in the postoperative period. In addition, because their Performance IQ test results were worse than Verbal IQ; and their Verbal IQ, Performance IQ, and total IQ points were also worse than the ADHD and control groups, we could suggest that they have more prevalence of disturbance of their visuospatial performance, material organization and attention than the control and ADHD groups. Finally we can hypothesize that all of these problems could produce maladaptation in the social, cultural, behavioral and academic areas (6, 14). So this study may open a way to evaluate and describe attention deficits of hydrocephalic children by using more specific neuropsychological tests. Although this study does not explain the details of the attention deficits of children with ADHD or with hydrocephalus; the

results suggest that the hydrocephalic children should be evaluated and detailed for their neuropsychological problems before and after the shunt surgery, and they should attend rehabilitation programs to improve their lives.

CONCLUSION

This prospective study showed that hydrocephalic children have attention deficits (sustain, focused/execute, and visuospatial attention) which might be directly caused by the hydrocephalus; and these deficits may cause serious adaptive problems in their social, cultural, behavioral and academic life.

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