Clock Face Drawing Test Performance in Children with ADHD

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A B S T R A C T

Introduction: The utility and discriminatory pattern of the clock face drawing test in ADHD is unclear. This study therefore compared Clock Face Drawing test performance in children with ADHD and controls.

Methods: 95 school children with ADHD and 191 other children were matched for gender ratio and age. ADHD symptoms severities were assessed using DSM-IV ADHD checklist and their intellectual functioning was assessed. The participants completed three clock-drawing tasks, and the following four functions were assessed: Contour score, Numbers score, Hands setting score, and Center score

Results: All the subscales scores of the three clock drawing tests of the ADHD group were lower than that of the control group. In ADHD children, inattention and hyperactivity/impulsivity scores were not related to free drawn clock test scores. When pre-drawn contour test was performed, inattentiveness score was statistically associated with Number score while none of the other variables of age, gender, intellectual functioning, and hand use preference were associated with that kind of score. In pre-drawn clock, no association of ADHD symptoms with any CDT subscales found significant. In addition, more errors are observed with free drawn clock and Pre-drawn contour than pre-drawn clock.

Discussion: Putting Numbers and Hands setting are more sensitive measures to screen ADHD than Contour and Center drawing. Test performance, except Hands setting, may have already reached a developmental plateau. It is probable that Hand setting deficit in children with ADHD may not decrease from age 8 to 14 years. Performance of children with ADHD is associated with complexity of CDT.

1. Introduction

Attention deficit hyperactivity disorder (ADHD) is a common psychiatric disorder with around 10 - 11% of school children reportedly affected in studies across cultures (Ghanizadeh 2008; Talaei, Mokhber et al. 2010; de la Barra, Vicente et al. 2012). ADHD symptoms is more common in boys than girls (Ghanizadeh 2008). The three main symptoms of ADHD are inattentiveness, hyperactivity, and impulsivity. Impulsivity and inattentiveness in children with ADHD is moderated by intelligence (Buchmann, Gierow et al. 2011).

Executive function of children with ADHD in comparison to children without ADHD is impaired in regard to planning, inhibition, working memory and cognitive

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control (Velez-van-Meerbeke, Zamora et al. 2012). Dopamine plays a key role in the executive system and- medications that impact on dopamine affect executive functions (Hosenbocus and Chahal 2012) Moreover, executive function deficits impairs everyday behavioral regulation (Shimoni, Engel-Yeger et al. 2012). Poorer executive function predicts poorer adaptive behavior (Ware, Crocker et al. 2012). In addition, executive function training may improve children's functioning (Johnson 2012). For example, working memory training indirectly improves academic function of children with ADHD (Green, Long et al. 2012). All of these items strongly suggest that executive function deficit should be screened as early as possible besides, Inattentiveness is associated with poorer hand writing and fine motor skills (Ghanizadeh 2010).

The Clock Drawing Test (CDT) is widely used for clinical screening of cognitive problems and monitoring of cognitive function in adults (Shulman 2000). It taps many skills and functions such as auditory comprehension, planning, executive function, organizational skills, concentration and abstract thinking (Shulman 2000). As such, it is not a diagnostic test, rather serving a complementary function. There are a number of CDT scoring systems (Freedman 1994; Cohen, Ricci et al. 2000) however, the psychometric properties of these different systems is very consistent (Shulman 2000). An advantage of the CDT is that it can be easily and quickly administered (Tranel, Rudrauf et al. 2008). In addition, the test is relatively independent of culture and language effects (Ismail, Rajji et al. 2010) and is usually well accepted by patients. It can differentiate individuals with mild cognitive impairment from healthy controls (Umidi, Trimarchi et al. 2009) although, in younger children, CDT performance is associated with hand use preference (Cohen, Ricci et al. 2000).

There are some reports about CDT performance of children with ADHD (Kibby, Cohen et al. 2002; Xiuhua and Ge 2005). While children with ADHD showed poorer performance on CDT in comparison to children without ADHD, the performance of children with inattentive type of ADHD was not different from combined type of ADHD (Kibby, Cohen et al. 2002). Another study also indicated similar findings (Meng-Long, Jin et al. 2007).

Indeed, CDT performance is influenced by brain functions mediated by the frontal and parietal lobes, and given the presence of cortical thinning cortex in children with ADHD, which is hypothesised that CDT performance of children with ADHD would be poorer than that of the general population. Previous studies have shown this poorer performance but had limitations. The current study therefore planned to match the groups for gender ratio and age (Kibby, Cohen et al. 2002). In addition, it is not known whether the patterns of inattentive and hyperactivity/impulsivity are associated with CDT performance in children with ADHD. Furthermore, it is not clear whether CDT performance of children with ADHD is influenced by age and gender. Moreover, to the best of authors' knowledge, no studied has investigated how different CDT tests with different levels of complexity correlate with function in ADHD. All of the previous studies tested children using a pre-drawn face clock. In the current study, we therefore used three different tests with different complexity. Impulsivity and inattentiveness in children with ADHD is moderated by intelligence (Buchmann, Gierow et al. 2011). Therefore, intellectual functioning was also considered as a covariate factor.

2. Methods

This case-control study included a clinical sample of 95 children with ADHD and a control group of 191 school children. The clinical sample was children referred to the Child and Adolescence psychiatry Clinics affiliated with Shiraz University of Medical Sciences. An ADHD diagnosis was made during a clinical interview using the Kiddie Schedule for Affective Disorders and Schizophrenia-Present and Lifetime Version (Ghanizadeh, Mohammadi et al. 2006) to a child and Adolescent psychiatrist based on the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders IV (DSM-IV) criteria (1994). The rater was a trained medicine student. The control group was randomly recruited from local schools. The randomization procedure was systematic random sample. Participants of both genders ranged from grade 3 to grade 8, were matched for gender ratio and age. A further inclusion criterion was that all of the participants had been taught clock reading in schools.

All children were off the stimulant medication for at least 6 hours before the timing of evaluation. Those with physical disability and serious medical conditions such as hypothyroidism were excluded. Another exclusion criterion was current use of medication that could influence on cognitive functioning, such as antihistamines. Learning disorders were not screened. We did not exclude children with learning disorders, as it is non-representative of the diagnostic group and findings cannot therefore be generalized to general population and children with ADHD.

The Ethics Committee of Shiraz University of Medical Sciences approved this study. Principals of the schools also agreed to conduct this study. Students provided their assent and/or written informed consent for their participation.

2.1. Procedures

All the participants were assessed individually. Children in the ADHD group were assessed in a stimulus free room in hospital and the children in the control group were assessed in schools. One of the authors conducted (S.S) all of the testing. The participants completed three clock-drawing tasks. In the first task, the children were asked to draw a clock contour. Then, they were asked to put the numbers in proper sites. They were also asked to draw clock hands and set time to 3:00. In the second task, a pre-drawn circle with a 10 centimeters diameter was provided. The children were told to put the numbers in the proper sites. They were also asked to draw clock hands and set time to 6:05. In the third task, a pre-drawn circle with proper numbers put in proper places was provided. Children were asked to draw hands and set time to 11:10. The children were not allowed to view clocks and watches during this testing.

The scoring system was based on instructions reported in the literature (Freedman 1994; Cohen, Ricci et al. 2000). In the free-drawn task, four functions were assessed including Contour score, Number score, Hands setting, and Center score: Contour consists of two questions, number score consists of 6, hands setting includes 6 and center score includes one question. All the questions are answered zero or one. Higher scores represent better condition. The two raters separately scored the results of 30 clocks. The inter-rater reliability for free drawn clock, Pre-drawn contour, and pre-drawn clock was 0.88, 0.69, and 0.86, respectively.

The two subtests of Block Design and Vocabulary from Wechsler Intelligence Scale for Children, 3rd edition (WISC-III) were assed to measure verbal and performance intellectual functioning (Wechsler and Corporation 1991). In the vocabulary subtest (VIQ), children are asked to describe some words as accurately as possible. Total IQ score was considered as a covariant factor.

ADHD symptoms severities were assessed using DSM-IV ADHD checklist, which has been used in previous studies, demonstrating satisfactory reliability and validity (Ghanizadeh and Jafari 2010). This checklist consists of 18 symptoms, nine of them are about inattentiveness and the other nine symptoms belong to hyperactivity/impulsivity criteria. It is a Likert type scale. Answers for each statement range from 0 to 3. Zero reflects lack of symptoms and 3 represents the worst condition. Inattentiveness score ranged from 0 to 27. Hyperactivity/impulsivity severity scores ranged from 0 to 27. In addition, demographic characteristics such as, age, gender, school grade, and hand use preference were recorded.

2.2. Statistical Analyses

SPSS -version of 16- was used to conduct analyses. An independent sample T test was performed in order to compare the mean of age of the two groups. Chi-square test was used to examine the association of gender and group.

Four separate linear regression analyses, backward methods, were conducted to examine whether there was any association among the variables of age, gender, inattentiveness score, hyperactivity/impulsivity score, verbal IQ score, performance IQ score, hand use preference, Contour score, Numbers score, hands setting score, and Center score in the ADHD group.

In addition, logistic regression analyses were performed to examine the association of age, gender, verbal IQ score, performance IQ score, hand use preference, Contour score, Numbers score, hands setting score, and Center score with group. Group was considered as a dependent variable. The alpha value less than 0.05 was set as statistical significance for all analyses.

3. Results

The age distribution of the two groups were as follows: ADHD group: range= 8 to 14, Mean=10.03, SD= 1.5; Control group: range= 8 to 14, Mean=10.3, SD= 1.5. The gender ratio of children in the ADHD and control groups was: percent of boys (n=66) =69.5% for ADHD group and (n=125) =65.4% boy's percentage for the other. The mean age of children in the two groups was not statistically different (t= 1.5, df= 284, P=0.11) and the gender ratio was similarly not statistically different between the two groups (X2=0.4, df=1, P=0.5). In the vocabulary subtest of the WISC-III, the range of responses in our study was from 2 to 19 (M = 15.8, SD = 3.8). The range of scores for performance subscale was from 1 to 18 (M = 9.9, SD = 3.5).

All the subscales scores of the three clock drawing tests of the ADHD group were lower than the score of the control group (Table 1). However, after considering the covariate factors, the findings were as follows:

Table 1. The mean and standard deviation of subscales scores of the three different clock drawing tests.

Subscales	Free draw clock		pre-drawn contour subscales scores		pre-drawn clock	
	ADHD group	Control group	ADHD group	Control group	ADHD group	Control group
Contour score	1.9(0.2)	1.9(0.2)	-	-	-	-
Numbers score	4.7(1.3)	5.3(0.9)	4.5(1.4)	5.3(1.0)	-	-
hands setting score	5.2(1.1)	5.3(0.6)	4.6(0.6)	4.9(0.3)	7.5(0.6)	7.8(0.4)
Center score	0.9(0.2)	1(0.01)	0.9(0.2)	1.0(0.01)	2.7(0.5)	2.9(0.2)

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Table 2. The association of group with age, gender, IQ scores, and free-drawn subscales scores.

Variable	Sig.	Exp(B)
Age	.9	.9
Gender	.4	.7
Vocabulary intellectual functioning	.001	1.1
Performance intellectual functioning	.001	1.1
Hand use preference	.2	1.7
Contour	.4	1.6
Number score	.003	1.5
Hands settin score	.03	1.5
Center drawing	.9	1.9

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3.1. ADHD Children

3.1.1. Free-drawn Clock

None of the variables was associated with the Contour score (P>0.05) and Numbers score (P>0.05). Hands setting score was significantly associated with age (P<0.002), verbal IQ score (P<0.04), and performance IQ score (P<0.02). Center score was only associated with verbal IQ score (P<0.002) in the ADHD group. Inattention score and hyperactivity/impulsivity score were not related to clock drawing test scores (P>0.05). Pre-drawn contour

Inattentiveness score (P<0.04) and verbal IQ score (P<0.02) were statistically associated with Number score. None of the other variables were associated with Number score. Hands setting was significantly associated with age (P<0.01), hyperactivity/impulsivity score (P<0.04), verbal IQ score (P<0.03), and performance IQ score (P<0.02) but was not associated with the scores of hand use preference, gender, and inattentiveness. Center score was only associated with hyperactivity/impulsivity score (P<0.03) in the ADHD group

3.1.2. Pre-drawn Clock

Hands setting score was only associated with age (P<0.001). None of the other variables were associated with Hands setting score. Only verbal IQ score was associated with Center score (P<0.001).

3.2. Patients Versus Control Groups

3.2.1. Free-drawn Clock

The logistic regression analyses showed that the variables of verbal IQ score, performance IQ score, Num-

Table 3. The association of group with age, gender, IQ scores, and pre-drawn contour subscales scores.

Variable	Sig.	Exp(B)
Age	.8	.9
Gender	.4	.7
Vocabulary intellectual functioning	.001	1.1
Performance intellectual functioning	.001	1.2
Hand use preference	.2	1.7
Numbers setting score	.01	1.3
Hands setting score	.4	1.3
Center drawing	.9	1.5

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Table 4. The association of group with age, gender, IQ scores, and pre-drawn clock face subscales scores.

Variable	Sig.	Exp(B)
Age	.5	.9
Gender	.2	.7
Vocabulary intellectual functioning	.001	1.1
Performance intellectual functioning	.001	1.2
Hand use preference	.3	1.5
Hands settin score	.02	1.8
Center Score	.09	2.03

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bers score, and hands setting score were statistically associated with group. The variables of age, gender, hand use preference, Contour score, and Center score were not associated with group (Table 2).

3.2.2. Pre-drawn Contour

Again, only Numbers score was associated with group. Hands score and Center score were not associated with group (Table 3).

3.2.3. Pre-drawn clock

In the third testing paradigm in which it was a pre-drawn circle with proper numbers put in proper places, Hands drawing score was associated with the group (Table 4).

4. Discussion

The current study compared the results of clock drawing tests between children with ADHD and the control group. In addition, this study examined whether ADHD children's clock drawing test ability was associated with inattention and hyperactivity/impulsivity severity, age, and gender. The first finding of this study is that clock drawing ability of ADHD children is poorer than that of age and gender matched children from a community sample. This results supports the findings reported by a previous study (Kibby, Cohen et al. 2002). The lack of association of inattentiveness and hyperactivity/impulsivity scores with clock drawing tests scores is also compatible with the results of another previously published study (Kibby, Cohen et al. 2002). However, the current results showed that Hands setting is associated with inattentiveness and hyperactivity/impulsivity severity in the pre-drawn contour of a clock.

It is consistent with the current literature that executive function of children with ADHD is more problematic than that of those control group (Velez-van-Meerbeke, Zamora et al. 2012). Since, intelligence was considered as a covariate factor, this difference cannot be explained by intelligence. Indeed, current results showed that the score of all the CDT subscales of children in ADHD group were less than that of the control group. However, after controlling for the covariate factors, only the two subscales of Number and Hands setting were different between the two groups. Children in the control group performed better than ADHD group. Therefore, it seems that Numbers score and Hands setting score are more sensitive measures to screen ADHD than Contour score and Center score when covariate factors are controlled for.

These results also showed that age was associated with hands setting score in the three types of Clock drawing tests. It can be assumed that other clock drawing performances including Contour drawing, Numbers setting, and Center items may have already reached a developmental plateau while Hands setting had not reached this plateau. Also, it can be assumed that this Hand setting deficit in children with ADHD will not decrease again from age 8 to age 14 years. These findings also support that hand setting ability in children with ADHD is not a developmental delay but may be a disability. Further longitudinal studies are needed to confirm this assumption. Clinically, some specific interventions should be feasible to target this problem. This disability was not observed when Pre-drawn clock CDT was performed (Table 4) while it was observed when the pre-drawn contour CDT was performed (Table 3). The different complexity of these two tests can be an explanation for this performance difference. When ADHD children faced a more complex task, they showed a poorer performance. However, this explanation is problematic because inattentiveness and hyperactivity/impulsivity scores were not associated with none of the free drawn clock test subscales. If the complexity was a factor responsible for weaker performance, it could be expected that inattentiveness and hyperactivity/impulsivity scores would be associated with the subscales of free drawn CDT. Meanwhile, Pre-drawn contour CDT was performed immediately after free-drawn CDT and inattentiveness and hyperactivity/impulsivity scores were related to the subscales of Pre-drawn contour CDT. One explanation is that although the complexity of Pre-drawn contour was less than free-drawn contour CDT, children with ADHD considerably lose their sustained attention or concentration after a while and this leads to poorer function for Pre-drawn contour in comparison to free-drawn contour CDT.

Gender was not associated with the subscales of CDT in none of the different types of CDT. We assume that CDT performance in children with ADHD is independent of gender.

A number of characteristics need to be noted in interpreting these data. This study included the three different types of CDT performances, as previous studies included only one type of CDT. In addition, the sample size of this study is larger than that of the previous study, and was powered sufficiently to find associations between inattentiveness and hyperactivity/impulsivity severity with CDT performances. No other tests of executive or frontal functions were however used as a reference point. Lastly, the broad inclusion criteria make it easier to generalize our results to total population.

CDT is associated with the frontal lobe function (Shoyama, Nishioka et al. 2011). In subjects with brain trauma, CDT performance is not limited to a specific lobe (de Guise, LeBlanc et al. 2010). However, impairments of CDT performance is more strongly associated with damage to right parietal cortices (supramarginal gyrus) and left inferior frontal-parietal cortices (Tranel, Rudrauf et al. 2008). Moreover, in ADHD the right superior frontal gyrus is thinner than that of controls and working memory is reduced (Fassbender, Schweitzer et al. 2011). Longitudinal studies are required to investigate whether CDT performance is influenced by ADHD treatment.

In conclusion, in children with ADHD, CDT performance is poorer than age and gender matched controls. Performance of children with ADHD on the CDT is associated with the task complexity. Hands setting appear more sensitive in screening of executive function of these children. It is however unclear if this is a remediable target.

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References

American Psychiatric Association, (1994), "Diagnostic and statistical manual of mental disorders", Washington, DC, American Psychiatric Association.

Buchmann, J., W. Gierow, et al. (2011). "Intelligence moderates impulsivity and attention in ADHD children: an ERP study using a go/nogo paradigm." World J Biol Psychiatry 12 Suppl 1: 35-9.

Cohen, M. J., C. A. Ricci, et al. (2000). "Developmental progression of clock face drawing in children." Child Neuropsychol 6(1): 64-76.

de Guise, E., J. LeBlanc, et al. (2010). "Neuroanatomical correlates of the clock drawing test in patients with traumatic brain injury." Brain Inj 24(13-14): 1568-74.

de la Barra, F. E., B. Vicente, et al. (2012). "Epidemiology of ADHD in Chilean children and adolescents." Atten Defic Hyperact Disord.

Fassbender, C., J. B. Schweitzer, et al. (2011). "Working memory in attention deficit/hyperactivity disorder is characterized by a lack of specialization of brain function." PLoS One 6(11): e27240.

Freedman, M. (1994). Clock drawing: a neuropsychological analysis, Oxford University Press, USA.

Ghanizadeh, A. (2008). "Distribution of symptoms of attention deficit-hyperactivity disorder in schoolchildren of Shiraz, south of Iran." Arch Iran Med 11(6): 618-24.

Ghanizadeh, A. (2010). "Predictors of different types of developmental coordination problems in ADHD: the effect of age, gender, ADHD symptom severity and comorbidities." Neuropediatrics 41(4): 176-81.

Ghanizadeh, A. and P. Jafari. (2010). "Cultural structures of the Persian parents' ratings of ADHD." J Atten Disord 13(4): 369-73.

Ghanizadeh, A., M. R. Mohammadi, et al. (2006). "Psychometric properties of the Farsi translation of the Kiddie Schedule for Affective Disorders and Schizophrenia-Present and Lifetime Version." BMC Psychiatry 6: 10.

Green, C. T., D. L. Long, et al. (2012). "Will Working Memory Training Generalize to Improve Off-Task Behavior in Children with Attention-Deficit/Hyperactivity Disorder?" Neurotherapeutics.

Hosenbocus, S. and R. Chahal (2012). "A review of executive function deficits and pharmacological management in children and adolescents." J Can Acad Child Adolesc Psychiatry 21(3): 223-9.

Ismail, Z., T. K. Rajji, et al. (2010). "Brief cognitive screening instruments: an update." Int J Geriatr Psychiatry 25(2): 111-20.

Johnson, M. H. (2012). "Executive function and developmental disorders: the flip side of the coin." Trends Cogn Sci 16(9): 454-7.

Kibby, M. Y., M. J. Cohen, et al. (2002). "Clock face drawing in children with attention-deficit/hyperactivity disorder." Arch Clin Neuropsychol 17(6): 531-46.

Meng-Long, W., J. Jin, et al. (2007). "The Executive Function Characteristics of Children with Attention Deficit Hyperactivity Disorder in Clock Drawing Test" Chinese Mental Health Journal: 01.

Shimoni, M., B. Engel-Yeger, et al. (2012). "Executive dysfunctions among boys with Attention Deficit Hyperactivity Disorder (ADHD): performance-based test and parents report." Res Dev Disabil 33(3): 858-65.

Shoyama, M., T. Nishioka, et al. (2011). "Brain activity during the Clock-Drawing Test: multichannel near-infrared spectroscopy study." Appl Neuropsychol 18(4): 243-51.

Shulman, K. I. (2000). "Clock-drawing: is it the ideal cognitive screening test?" Int J Geriatr Psychiatry 15(6): 548-61.

Talaei, A., N. Mokhber, et al. (2010). "Attention deficit/hyperactivity disorder: a survey on prevalence rate among male subjects in elementary school (7 to 9 years old) in Iran." J Atten Disord 13(4): 386-90.

Tranel, D., D. Rudrauf, et al. (2008). "Does the Clock Drawing Test have focal neuroanatomical correlates?" Neuropsychology 22(5): 553.

Umidi, S., P. D. Trimarchi, et al. (2009). "Clock drawing test (CDT) in the screening of mild cognitive impairment (MCI)" Arch Gerontol Geriatr 49 Suppl 1: 227-9.

Velez-van-Meerbeke, A., I. P. Zamora, et al. (2012). "Evaluating executive function in schoolchildren with symptoms of attention deficit hyperactivity disorder." Neurologia.

Ware, A. L., N. Crocker, et al. (2012). "Executive Function Predicts Adaptive Behavior in Children with Histories of Heavy Prenatal Alcohol Exposure and Attention-Deficit/Hyperactivity Disorder." Alcohol Clin Exp Res 36(8): 1431-1441.

Wechsler, D. and P. Corporation. (1991). "WISC-III: Wechsler intelligence scale for children", The Psychological Corporation San Antonio.

Xiuhua, Z. and F. Ge (2005). Clock Drawing Test and Clock Drawing Test in ADHD Children. Advances In Psychological Sciences, 2005, Vol. 13 Issue (05): 651-657