Kaohsiung Journal of Medical Sciences (2016) 32, 630–633

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.kjms-online.com

SHORT COMMUNICATION

Poor performance of fine motor activity among biological parents of children with attention deficit/hyperactivity disorder

Ni Chun Hung [a,b], Shih-Hsien Lin [c,d], Mei Hung Chi [c], Chien-Ho Lin [a,e], Po See Chen [c,d], I Hui Lee [c,d], Kao Chin Chen [c,d], Yen Kuang Yang [c,d,*]

[a] *Department of Psychiatry, Chi Mei Medical Center, Tainan, Taiwan*
[b] *Institute of Behavioral Medicine, College of Medicine, National Cheng Kung University, Tainan, Taiwan*
[c] *Department of Psychiatry, National Cheng Kung University Hospital, College of Medicine, National Cheng Kung University, Tainan, Taiwan*
[d] *Addiction Research Center, National Cheng Kung University, Tainan, Taiwan*
[e] *Department of Senior Citizen Service Management, College of Recreation and Health Management, Chia Nan University of Pharmacy and Science, Tainan, Taiwan*

Received 1 July 2016; accepted 2 September 2016
Available online 27 October 2016

KEYWORDS
Attention deficit hyperactivity disorder (ADHD);
Dopamine;
Endophenotype;
Finger tapping test (FTT);
Nondominant hand

Abstract It has been proposed that the dopaminergic system and heritability may play roles in attention deficit/hyperactivity disorder (ADHD). We assessed the performance of healthy parents of children with ADHD in the finger tapping test (FTT) in this study, which is a reliable test and sensitive to central dopamine activity. A total of 16 parents of children with ADHD and 32 controls were enrolled. The FTT was conducted. The 16 healthy parents of children with ADHD exhibited a significantly poorer performance in the FTT, using the nondominant hand, than the 32 healthy controls. This finding indicated that poor motor function could be a potential characteristic in parents of offspring with ADHD.

Conflicts of interest: All authors declare no conflicts of interest.
* Corresponding author. Department of Psychiatry, National Cheng Kung University Hospital, 138 Sheng Li Road, North District, Tainan 70403, Taiwan.
E-mail address: ykyang@mail.ncku.edu.tw (Y.K. Yang).

http://dx.doi.org/10.1016/j.kjms.2016.10.001

Introduction

Animal [1] and human neuroimaging studies [2,3] have confirmed that central dopaminergic activity is associated with motor activity. Evidence from pharmacological, gene, and neuroimaging studies has supported the role of the dopamine system in the etiology of attention deficit/hyperactivity disorder (ADHD) [4—6]. It was also found that heritability could be an important factor in ADHD [7]. Because genetic factors play important roles in the etiology of ADHD, understanding the endophenotype could be an important topic. Endophenotype may refer to "a phenotype more proximal to the biological etiology of a clinical disorder than its signs and symptoms and influenced by one or more of the same susceptibility genes as the condition" [8]. It was found that unaffected siblings of children with ADHD have different performance on the endophenotypes, as phenotypes [9].

Although little is known about the motor and cognitive function among healthy parents of children with ADHD, a weak association between motor control on a computerized pursuit task and ADHD symptoms was found [10]. It had been established that dopamine activity could be related to fine motor performance. For example, hypodopaminergic tone was found to be related to the poor motor performance among patients with Parkinson's disease and could be reversed by dopamine agonist [11]. In addition, extrapyramidal motor symptoms could be considered another example of poor motor performance due to altered dopamine function [12]. The finger tapping test (FTT) is considered a sensitive marker for dopaminergic function, as supported by brain imaging studies with positron emission tomography or single-photon emission computed tomography, reporting a negative correlation between dopamine D_2 receptors and transporter availability [2,3]. Large sample size studies indicated that individuals with a tendency toward ADHD and those without the tendency toward it have similar performance in the tapping task [13,14], but whether the performance in the FTT of healthy parents of children with ADHD could be poorer is unclear. The aim of the present study was to compare the performance in the FTT between the healthy parents of children with ADHD and the controls.

Methods

Participants

We enrolled 16 healthy parents (13 males and 3 females) of children with ADHD from the child psychiatry outpatient clinics of a university hospital. The inclusion criteria were as follows: (1) a child who fulfilled the *Diagnostic and Statistical Manual of Mental Disorders—Fourth Edition* (DSM-IV) criteria for child ADHD; (2) the results of the Edinburgh Handedness Inventory show non-left-handedness in all participants.

A group of healthy controls ($N = 32$) with a similar number of years of education and score of full-scale IQ, without a child who fulfilled the DSM-IV criteria for child ADHD, matched in terms of sex and age, were also enrolled from the community. All participants were confirmed by a senior psychiatrist to be free of any psychological disorder, including ADHD, using the MINI Neuropsychiatry Interview and had not received any medication for more than 3 months.

Before any procedure was performed, written informed consent was obtained from the participants. The Ethics Committee for Human Research at the National Cheng Kung University Hospital approved the study protocol.

Finger tapping test

The FTT was used to measure the motor speed of the index finger of each hand. The finger tapping score is defined as the mean number of taps per 10 seconds collected over five trials. Using a specially adapted tapper, the participant tapped as fast as possible using the index finger of each hand [15].

Wechsler Adult Intelligence Scale—Revised

The Wechsler Adult Intelligence Scale—Revised (WAIS-R) [16] was used to evaluate individual intelligence. This test gives a full-scale IQ (FIQ) and two dimensions of IQ. The six-subtest short-form combination was composed of digit symbol, block design, object assembly, digit span, similarity, and arithmetic tests. We used the former three to obtain an estimated performance IQ (PIQ) and the latter three to obtain an estimated verbal IQ (VIQ). The mean FIQ score in this test is 100. (The standard deviation is 15.)

Statistics

Because the sample size was small, the Mann—Whitney *U* test was used to examine the differences in age, years of education, IQ, and performance in the FTT between groups. Supplemental *t* test and analysis of covariance were used to test the robustness of the finding prior to and after controlling for the effect of age. The level of significance was set at $p < 0.05$ (two-tailed). All analyses were performed using SPSS software (version 17.0; SPSS Inc., Chicago, IL, USA).

Results

No significant differences were found in terms of age, years of education, or performance in the WAIS-R between groups, as shown in Table 1. The performance in the FTT of the dominant hand (the dominant hand is the right hand for all participants in this study, as confirmed by Edinburgh Handedness Inventory) did not differ significantly. The parents of children with ADHD exhibited a significantly poor performance in the FTT of the nondominant hand, as illustrated in Figure 1. Supplemental analysis indicated that this finding remains significant prior to ($T = -2.32$, $p = 0.02$) and after controlling for the effect of age ($F = 5.57$, $p = 0.02$).

Table 1 Demographic data, cognitive function, and motor performance of the parents of children with ADHD and their matched healthy controls.

	Parents of children with ADHD (n = 16)	Healthy controls (n = 32)	Statistics	
	Mean ± SD	Mean ± SD	Mann—Whitney U	p
Age	41.50 ± 7.00	41.82 ± 7.13	−0.13	0.90
Years of education	13.25 ± 3.40	13.69 ± 2.68	−0.64	0.52
WAIS-R				
Performance IQ	108.75 ± 15.19	111.22 ± 14.89	−0.69	0.49
Verbal IQ	105.75 ± 14.63	111.25 ± 17.95	−0.93	0.35
Full-scale IQ	107.38 ± 14.76	111.88 ± 16.75	−0.98	0.32
FTT				
Dominant hand	48.11 ± 7.45	50.55 ± 7.62	−1.04	0.30
Nondominant hand	42.73 ± 4.69	46.93 ± 6.44	−2.02	0.04

ADHD = attention deficit/hyperactivity disorder; FTT = finger tapping test; IQ = intelligence quotient; SD = standard deviation; WAIS-R = Wechsler Adult Intelligence Scale—Revised.

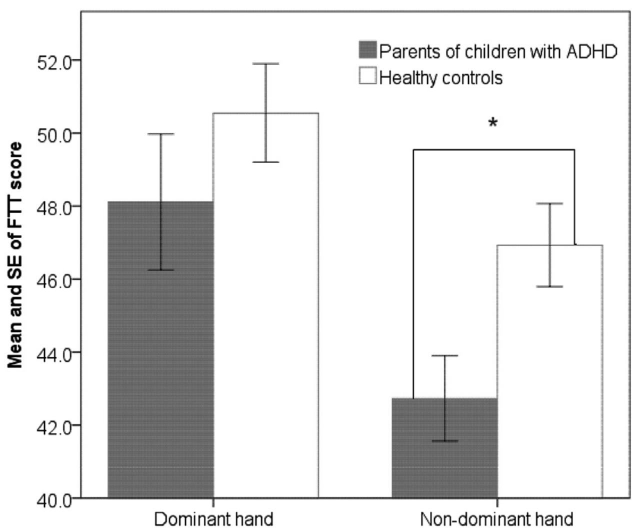

Figure 1. Performance in the FTT of the parents of children with ADHD and healthy controls. *$p < 0.05$. ADHD = attention-deficit/hyperactivity disorder; FTT = finger tapping test; SE = standard error.

Discussion

The results indicated that the parents of children with ADHD, although they have cognitive function similar to the controls, may still have a poorer motor performance of the nondominant hand. The poor performance in the FTT of the parents of children with ADHD may result from altered dopaminergic function [2,3], which is considered a primary etiology of ADHD [4—6]. The present findings may imply that poor motor function is a potential characteristic of parents of offspring with ADHD.

A poor performance in the FTT among the parents of children with ADHD was only identified for the nondominant hand and not for the dominant hand. Currently, the mechanism of this phenomenon is unclear. Children with ADHD have been shown to be much slower in a tracking task and a pursuit task with the nondominant hand than healthy controls [17]. Klotz et al [18] also found a difference in speed with the nondominant hand in the sequential thumb—finger opposition test, a test for the assessment of motor function, compared to typically developed children. In addition, compared with healthy controls, children with ADHD have slower and more variable reaction times (RTs) [18]. RT can be a measure of sustained attention in a model of attention as well as a measure of the preparation for movement in a model of motor control. Pedersen et al [19] found that children with ADHD had a slower movement preparation. This indicated that they perform poorly in terms of timing ability, referring to the ability to deal with the temporal domain in behavior. Neurocognitive and neuroimaging studies have indicated that individuals with ADHD may have deficits in a range of timing functions and their underlying neural networks [20]. One of the important components of the FTT score is RT. Whether the difference effects on dominant and nondominant hand are associated with other biological mechanisms is unclear. Our finding indicated that there is no significant group difference on the FTT of the dominant hand between healthy parents with children who have ADHD and healthy controls. We speculated that the difficulty of tapping with the dominant hand among healthy individuals is not challenging. Therefore, low dopamine activity cannot alter the performance of patients with ADHD in this circumstance. It was found that the small variation in the tapping rate of the dominant hand [21] may imply that the motor performance in the dominant hand is less vulnerable to the effect of hypodopamine function. Also, it is worth noting that ADHD has been proposed as a right-hemisphere deficit [22,23]. Whether there is lateralization among the parents of ADHD could be an important issue. The discrepancy between dominant and nondominant hand in our study could also be attributable to the effect of lateralization.

The results of the present small sample study need to be interpreted with caution for several reasons. First, the possibility of type 2 statistical errors cannot be fully excluded because this study included only a small sample. Second, the FTT may reflect a certain part—but not the whole domain—of motor performance. Third, most of the participants were male, and whether this phenomenon can be replicated among females is unclear. Fourth, whether this phenomenon can be found in other tasks of manual dexterity, such as in the Grooved Pegboard test, is unclear. Fifth, we did not enroll a group of adults with ADHD with similar age in our study. Because the dopamine level may decline with age, a group of comparably aged adults with ADHD is needed for testing whether FTT or other motor performance could be an endophenotype.

A poor performance in the FTT of the nondominant hand was found among the parents of children with ADHD. We suggest that poor motor function might be a potential behavior marker in healthy parents of children with ADHD. As to whether FTT is altered among people with ADHD of similar age (more than 40 years old on average) is unclear; the potential role of FTT as an endophenotype remains to be elucidated.

Acknowledgments

This study was supported in part by grants from the National Science Council of Taiwan (NSC 101-2314-B-006-065 and NSC 102-2420-H-006-007-MY2) and Chi Mei Medical Center (CMNCKU10312). This research also received funding (D102-35001 and D103-35A09) from the Headquarters of University Advancement at the National Cheng Kung University, which is sponsored by the Ministry of Education, Taiwan, ROC. The authors thank Mr Chien Ting Lin and Ms Tsai Hua Chang of the Department of Psychiatry, National Cheng Kung University Hospital, in addition to the participants in this study.

References

[1] Centonze D, Grande C, Saulle E, Martin AB, Gubellini P, Pavon N, et al. Distinct roles of D1 and D5 dopamine receptors in motor activity and striatal synaptic plasticity. J Neurosci 2003;23:8506—12.
[2] Volkow ND, Gur RC, Wang GJ, Fowler JS, Moberg PJ, Ding YS, et al. Association between decline in brain dopamine activity with age and cognitive and motor impairment in healthy individuals. Am J Psychiatry 1998;155:344—9.
[3] Yang YK, Chiu NT, Chen CC, Chen M, Yeh TL, Lee IH. Correlation between fine motor activity and striatal dopamine D2 receptor density in patients with schizophrenia and healthy controls. Psychiatry Res 2003;123:191—7.
[4] Dresel S, Krause J, Krause KH, LaFougere C, Brinkbaumer K, Kung HF, et al. Attention deficit hyperactivity disorder: binding of [99mTc]TRODAT-1 to the dopamine transporter before and after methylphenidate treatment. Eur J Nucl Med 2000;27:1518—24.
[5] Volkow ND, Wang GJ, Newcorn J, Fowler JS, Telang F, Solanto MV, et al. Brain dopamine transporter levels in treatment and drug naive adults with ADHD. Neuroimage 2007;34:1182—90.
[6] Cook Jr EH, Stein MA, Krasowski MD, Cox NJ, Olkon DM, Kieffer JE, et al. Association of attention-deficit disorder and the dopamine transporter gene. Am J Hum Genet 1995;56: 993—8.
[7] Faraone SV, Doyle AE. The nature and heritability of attention-deficit/hyperactivity disorder. Child Adolesc Psychiatr Clin N Am 2001;10:299—316. viii—ix.
[8] Doyle AE, Willcutt EG, Seidman LJ, Biederman J, Chouinard V-A, Silva J, et al. Attention-deficit/hyperactivity disorder endophenotypes. Biol Psychiatry 2005;57:1324—35.
[9] Rommelse N, Altink ME, Martin NC, Buschgens CJ, Faraone SV, Buitelaar JK, et al. Relationship between endophenotype and phenotype in ADHD. Behav Brain Funct 2008;4:4.
[10] Polderman TJ, Huizink AC, Verhulst FC, van Beijsterveldt CE, Boomsma DI, Bartels M. A genetic study on attention problems and academic skills: results of a longitudinal study in twins. J Can Acad Child Adolesc Psychiatry 2011;20:22—34.
[11] Lemke MR, Brecht HM, Koester J, Reichmann H. Effects of the dopamine agonist pramipexole on depression, anhedonia and motor functioning in Parkinson's disease. J Neurol Sci 2006; 248:266—70.
[12] Scherer J, Tatsch K, Schwarz J, Oertel WH, Konjarczyk M, Albus M. D2-dopamine receptor occupancy differs between patients with and without extrapyramidal side effects. Acta Psychiatr Scand 1994;90:266—8.
[13] Rommelse NN, Altink ME, Oosterlaan J, Beem L, Buschgens CJ, Buitelaar J, et al. Speed, variability, and timing of motor output in ADHD: which measures are useful for endophenotypic research? Behav Genet 2008;38:121—32.
[14] Meyer A, Sagvolden T. Fine motor skills in South African children with symptoms of ADHD: influence of subtype, gender, age, and hand dominance. Behav Brain Funct 2006;2:33.
[15] Prigatano GP, Johnson SC, Gale SD. Neuroimaging correlates of the Halstead Finger Tapping Test several years post-traumatic brain injury. Brain Inj 2004;18:661—9.
[16] Wechsler D. Wechsler Adult Intelligence Scale—revised manual. London: Psychological Corporation; 1986.
[17] Rommelse NN, Altink ME, Oosterlaan J, Buschgens CJ, Buitelaar J, De Sonneville LM, et al. Motor control in children with ADHD and non-affected siblings: deficits most pronounced using the left hand. J Child Psychol Psychiatry 2007; 48:1071—9.
[18] Klotz JM, Johnson MD, Wu SW, Isaacs KM, Gilbert DL. Relationship between reaction time variability and motor skill development in ADHD. Child Neuropsychol 2012;18:576—85.
[19] Pedersen SJ, Surburg PR, Heath M, Koceja DM. Fractionated lower extremity response time performance in boys with and without ADHD. Adapt Phys Activ Q 2004;21:315—29.
[20] Noreika V, Falter CM, Rubia K. Timing deficits in attention-deficit/hyperactivity disorder (ADHD): evidence from neurocognitive and neuroimaging studies. Neuropsychologia 2013; 51:235—66.
[21] Todor JI, Kyprie PM. Hand differences in the rate and variability of rapid tapping. J Mot Behav 1980;12:57—62.
[22] Hale TS, Loo SK, Zaidel E, Hanada G, Macion J, Smalley SL. Rethinking a right hemisphere deficit in ADHD. J Atten Disord 2009;13:3—17.
[23] Miller SR, Miller CJ, Bloom JS, Hynd GW, Craggs JG. Right hemisphere brain morphology, attention-deficit hyperactivity disorder (ADHD) subtype, and social comprehension. J Child Neurol 2006;21:139—44.