ORIGINAL ARTICLE

MOTOR COORDINATION PERFORMANCE DIFFERENCES BETWEEN SCHOOL CHILDREN WITH AND WITHOUT DEVELOPMENTAL COORDINATION DISORDER ATTENDING INTEGRATIVE SPECIAL EDUCATION IN KLANG VALLEY

Nor Azizah Mohamad[1,2], Yip Yee Ern[1], Nor Azlin Mohd Nordin[1] and Asfarina Zanudin[1]

[1]Physiotherapy Program, Centre for Rehabilitation and Special Needs, Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz, 50300 Kuala Lumpur, Malaysia.
[2]Physiotherapy Unit, Department of Medical Rehabilitation Services, Universiti Kebangsaan Malaysia Medical Centre, Jalan Yaacob Latif, Bandar Tun Razak, 56000 Kuala Lumpur, Malaysia.

Corresponding author:
Nor Azlin Mohd Nordin
Email: norazlin8@ukm.edu.my

ABSTRACT

Children with Developmental Coordination Disorder (DCD) have impairments in gross and fine motor skills consequently limit their participation in school activities. The aim of this study was firstly to evaluate motor coordination performance of children with DCD in manual dexterity, hand-eye coordination and balance skills, and secondly, to compare the motor coordination performance between children with DCD and age-matched children without DCD. A total of 47 children with DCD (32 boys, 15 girls) and 16 children without DCD (15 boys, 1 girl) aged between 7 to 10 years old participated in this study. They were recruited from integrative special education classes from six selected primary schools within Klang Valley. The Movement Assessment Battery for Children-2 (MABC-2) evaluated their motor coordination performance. Group differences on the MABC-2 subtest scores and total test score were analysed using independent t-test. Cohen's d was calculated to obtain the effect size of clinical differences. Children with DCD showed significantly lower score in manual dexterity (p=0.001), aiming and catching (p=0.001), balance test (p=0.001) and total test score (p=0.001) compared to the children without DCD. Effect sizes on manual dexterity (d=0.52), balance (d=0.68), and total test score (d=0.73) indicated moderate clinical differences between the two groups. In conclusion, children with DCD showed deficits in both gross and fine motor skills performance based on the MABC-2 subtests and total test score, in comparison with children without DCD. School-based rehabilitation to improve gross and fine motor problems among the children is warranted.

Key words: *Developmental Coordination Disorder, manual dexterity, aiming and catching, balance*

INTRODUCTION

Developmental coordination disorder (DCD) is a common developmental disorder affecting many school children worldwide. DCD occurs approximately in 5-8% of school children aged between 6 to 12 years old[1]. Boys are two times more likely to be affected than girls[2]. The aetiology of DCD is idiopathic, however many studies reported that children who were born preterm and/or with low birth weight were at higher risk to exhibit DCD characteristics during their school age[3,4] than their term-born peers and this might relate to the atypical brain development[5]. DCD is characterized by deficits in motor skill coordination such as clumsiness in manipulating objects and writing as well as dropping things from hands[6].

Clinicians often use the Movement Assessment Battery for Children (MABC) as one of the methods of identifying children with DCD[7] as well as to test the motor coordination in children[8]. Waelvelde and colleagues[9] conducted a study in thirty-six children with and without DCD aged 9-10 years and reported the mean (SD) for MABC total score was 23.69(6.67) and 4.63(2.63) in DCD and without DCD groups, respectively. The researchers also reported large effect size (*d*=3.62) of clinical difference between children with and without DCD in the MABC score of >15th percentile. Tsai and Wu (2008)[10] who investigated motor impairment in children with and without DCD aged 9-10 years revealed significant difference ($p<0.05$) in terms of MABC total score between children with DCD (mean score 17.93±3.45) and without DCD (mean score 5.78±2.41). In addition, the effect size was large (*d*=1.79) between the two groups. No study has reported the prevalence of DCD among children in Malaysia using the standardised outcome measure.

In Malaysia, majority of the children with special needs such as autism spectrum disorder (ASD), dyslexia, DCD, Down syndrome and cerebral palsy receive integrative special education in formal primary and secondary government mainstream schools. Children with DCD can exhibit a combination of one or more impairments in the joint proprioception, motor programming, postural

control and timing or sequencing of muscle activities. In addition, these children also experience deficits in visual-spatial processing[11], controlling movement force, timing the movement[12,13] and rhythmic hand/foot inter-limb coordination[14,15]. The children with DCD may also present with emotional and behaviour issues such as attention deficit, impulsiveness, low self-esteem, depression and anxiety[16-18]. Early detection of children with DCD in special education school settings would not just benefit the children and their family; it will help the teacher, school and community as studies showed early intervention lead to improvement of motor performance and quality of life[19,20].

Studies which screen motor coordination performance among pupils with special needs remain scarce in Malaysia. The primary aim of this study was to evaluate three subtests of motor coordination performance; namely manual dexterity, aiming and catching and balance items, on children with DCD in Malaysian primary school settings. Secondly, this study aimed to compare their motor skills performance with the age-matched children without DCD. The outcomes of this screening will propose appropriate physiotherapy interventions to be conducted at the primary school setting.

METHODOLOGY

Study Design and Location

This cross-sectional study was conducted in six selected primary schools in Klang Valley from February to May 2016, and involved school children who are attending special education class. The study was approved by the Research Ethic Committee of Universiti Kebangsaan Malaysia and the Ministry of Education.

Participants

Sixty three children (47 boys, 16 girls) were recruited using specific inclusion criteria which were (1) aged 7-10 years old, (2) able to obey commands, and (3) able to write and read simple phrases/sentences. The children were then categorised into either a DCD or without DCD group. For children in the DCD group, the specific criteria were: (1) diagnosed with DCD by paediatrician and (2) score <15th percentile on the Movement Assessment Battery for Children-2 (MABC-2) total score. For children in 'without DCD' group the specific criteria was a score above 15th percentile on the MABC-2 total test. All MABC-2 tests were performed by the main researcher in the school setting.

Children with (1) underlying neurological lesions, such as cerebral palsy, neuromuscular disease and genetic disease; (2) neurodevelopmental disorder such as autism spectrum disorder, (3) severe learning difficulty (4) ssignificant visual and hearing impairment to the extent that impede them from performing the motor tasks and (5) the use of wheelchair or assistive device to move around were excluded from the study.

Procedure

Headmasters and special education teachers of the six selected primary schools were contacted and informed regarding the study objectives and procedures approximately one week before the participants' screening. The parents of the potential participants were contacted to obtain informed consent, during which they had an opportunity to clarify any doubts related to the study. Potential participants were initially screened by their teachers using the MABC-2 checklists.

Assessment of motor performance took place in the schools hall and was conducted by the primary investigator (NAM) and a trained physiotherapy student (YYE). Each participant was instructed to perform eight items of the MABC-2, consisting of manual dexterity (3 items), aiming and catching (2 items) and balance (3 items) constructs. All instructions were given based on guidelines in the MABC-2 manual book[8].

Measurement tool: Movement Assessment Battery for Children Version 2 (MABC-2)

The MABC-2, an updated version of the MABC[8] was used to assess motor performance of the participants. This is a commonly used tool among children with DCD and has been shown to be valid and reliable to assess the coordination difficulties in children between 3 to 16 years old[8]. The MABC-2 scale is divided into three age bands i.e. 3 to 6-year old, 7 to 10-year old and 11- 16 years old. The assessment contains eight physical tasks under three main subtests i.e. manual dexterity, aiming and catching and balance. The assessment takes approximately 20 to 35 minutes to complete. The raw scores for each item were converted into standard scores. The individual standard scores were summed up into Total Test Score (TTS) and percentile equivalent was obtained. Percentile ranks indicate the severity of movement difficulties, in which the lower the percentile, the poorer the motor performance. Participants with TTS below 5th percentile are regarded as 'having a significant motor difficulty' or being in 'red zone', while those with score between 6th and 15th percentile is assumed as 'at risk of having movement difficulty' or being in 'amber zone'. TTS score above 15th percentile is categorised as 'green zone' or 'having no movement difficulty'[8].

Data analysis

Data analyses were performed using the Statistical Package for Social Sciences (SPSS) version 23. Descriptive data of participants was presented in number, percentage, mean and standard deviation. Independent t-test was used to compare the MABC subtests score (manual dexterity, aiming and catching, balance) and total test score between the DCD and without DCD groups. Results were considered significant if *p* values were less than 0.05. In addition, the effect sizes (*d*) were calculated for clinical differences; 'small' if *d*= 0.2-0.49, 'moderate' if *d*=0.5-0.79, and 'large' if *d*>0.8[21].

RESULTS

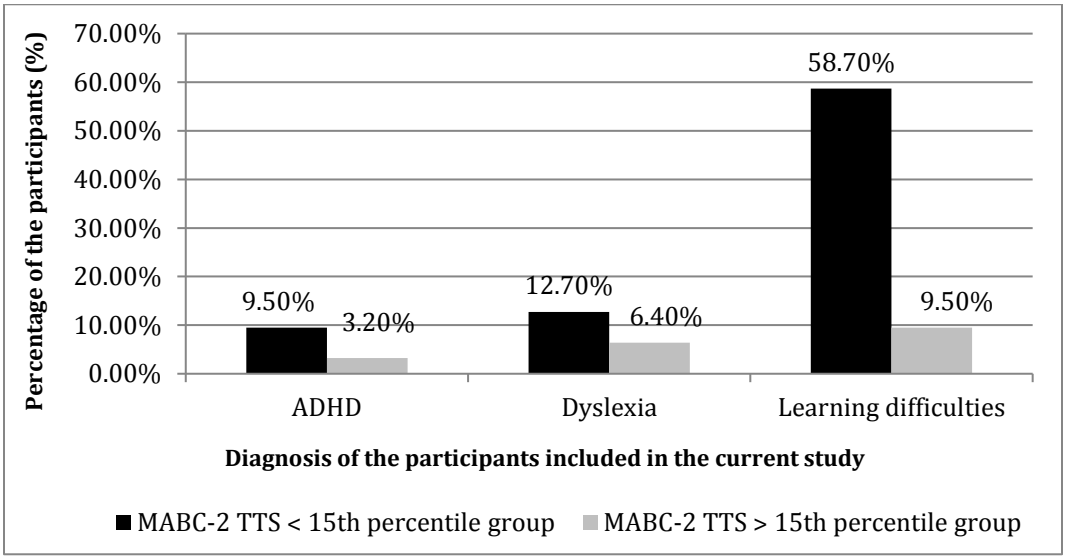
Out of the 63 children who participated in this study, majority of them have learning difficulties (69.84%), 17.46% diagnosed with dyslexia and 12.7% with attention deficit hyperactive disorder (ADHD). Fifty one children (35 boys, 16 girls) were identified as DCD and 12 (all boys) were categorized as 'without DCD' based on the results of MABC total score; this indicated 80.95% of the participants are having some forms of movement difficulty. The mean age of the DCD group was 8.53 ± 1.01 years, while the mean age of without DCD group was 9.06 ± 1.12 years. Table 1 shows the demography of the children with DCD and without DCD included in the study.

Table 1: ***Demography of children with and without DCD***

Demography characteristics	DCD (n=51)	without DCD (n=12)
Mean age ± SD (years)	8.53 ± 1.01	9.06 ± 1.12
Gender (Male/Female) (n)	35/16	12/0
Diagnosis (ADHD/Dyslexia/Learning disabilities)	6/8/37	2/3/7

Figure 1 shows the percentage of participants who scored <15th and >15th percentile on the MABC based on diagnosis. Majority of the participants (58.7%) who scored <15th percentile on the MABC are children with a diagnosis of learning disabilities, followed by children with dyslexia (12.70%). When analysis within the sub-group of diagnosis was done, it was found that 86% of the 44 children with learning difficulties scored <15th percentile on the MABC total score.

Figure 1: ***The percentage of participants who scored <15th and >15th percentile on MABC based on diagnosis***.



Comparison of the mean score for subtests and total score revealed that the children with DCD had significantly lower score than their 'without DCD' peers in manual dexterity, aiming and catching and balance tasks (Table 2). The effect sizes (d) were 0.52 for manual dexterity, 0.68 for balance, and 0.73 for total test score, which indicate moderate clinical difference between children with and without DCD. Small effect size (*d*=0.40) was found for aiming and catching task between the two groups.

Table 2: ***Mean scores (SD) for MABC-2 sub-tests and total score among children with and without DCD***

	Score <15th percentile (DCD) Total (n=51)	Score > 15th percentile (without DCD) Total (n=12)	*p* value
Manual dexterity	13.53 ± 5.24	25.96 ± 5.20	0.001
Aiming and catching	10.04 ± 2.58	15.81 ± 4.34	0.001
Balance	16.72 ± 7.85	31.06 ± 1.96	0.001
Total test score	40.02 ±12.43	72.81± 6.97	0.001

DISCUSSION

The main aim of this study was to evaluate the motor performance of children with DCD in special education schools setting. Results showed that more than three quarter of the children scored <15th percentile on MABC-2. The finding from this study concurs with findings from a study by Vuijk and colleagues (2011)[22] who found that 81.8% children with mild intellectual disability and 60.0% with borderline intellectual functioning scored <15th percentile on MABC. The researchers also reported that, of the three subtests of MABC, more than half of the children scored <15th percentile in manual dexterity test. Liu and Breslin[23] whom examined motor performance of children with autism spectrum disorders (ASD) found that 80% of the children were classified in the red and amber zones according to the MABC-2 manual. Despite the report that most children with ASD were high functioning, several researches revealed that they might also have dyspraxia or motor clumsiness problem[24-26]. Children with ASD also commonly present with impairment of communication skill that interfere with their social functioning when receiving primary education under special education system. Although this current study did not evaluate the motor performance of specifically children with ASD but assessed learning difficulties in general, the finding of motor coordination problems among the children who attended special education classes is useful for therapists who manage children with special needs.

The second aim of this study was to compare the motor performance of children with and without DCD based on the MABC scores. The study found that the DCD group scored significantly lower in all three subtests of MABC than the 'without DCD' group. This finding is in agreement with a study by Wang and colleagues (2009) who reported that both DCD and 'suspicious' DCD groups scored significantly lower than a group of children without motor problems in three subtests of daily living. In their study, the Vineland Adaptive Behaviour Scale (VABS) with three subtests namely personal living skill, gross motor and fine motor was used[6]. The lower scores indicate that children with DCD might struggle with their daily activities at school and home[9].

Several studies have reported positive outcomes following motor interventions performed by therapists at schools[12,27-29]. The results from this current study concur that therapists who manage rehabilitation program for children with DCD should focus on improving motor performance among the children in the school setting. Training of gross motor skills or task-oriented activities can be conducted during physical education time, and manual dexterity skills as well as writing skill can be trained during manipulative training time. The existing education module for children with special needs at schools may need to be reviewed to include strategies to maximise these training times. Ideally, the physical education for students with movement problems should be conducted differently from students who are physically-abled, and consideration given to the type, mode and goals of exercises. Special education teachers may not be suitable persons to implement these recommended activities, compared to an expert in movement analysis and rehabilitation such as physiotherapist. We recommend that physiotherapists are allocated in schools with special education classes to assist children with DCD in motor performance activities other than occupational therapist and speech language pathologist. The importance of providing disabled friendly environment including specific training or therapies to increase independency among children with special needs in schools has been highlighted in a previous local study[32].

One of the limitations of this study was it only involved children with DCD in the Klang Valley, which limits the generalisability of its results. Larger sample size and with inclusive of children with other diagnosis of movement impairment is required for future studies, to strengthen recommendation for physiotherapy-led rehabilitation services in public integrative special education programs.

CONCLUSION

The strength of the current study is the use of MABC, a specific measure of motor coordination in assessing and reporting DCD in special education

schools setting. This study indicates that children with DCD are slower in fine and gross motor skills compared to age-matched children without DCD who are also attending special education program. Early detection of motor problems using MABC and implementation of school-based rehabilitation are recommended to improve physical activity performance of children in special education program.

ACKNOWLEDGEMENT

We thank the children and their parents, and all special education teachers for their participation in this study.

REFERENCES

1. Barnhart RC, Davenport MJ, Epps SB, et al. Developmental coordination disorder. *Physic Ther* 2003; **83**(8):722-31.

2. American Psychiatric Association. DSM-IV-TR Diagnostic and Statistical Manual of Mental Disorders. Washington, DC: APA, 2000.

3. Zanudin A, Gray PH, Burns Y, Danks M, Watter P, Poulsen L. Perinatal factors in non-disabled ELBW school children and later performance. *Journal of paediatrics and child health* 2013; 49(1)

4. Edwards J, Berube M, Erlandoson K, et al. Developmental Coordination Disorder in school-aged children born very preterm and/or at very low birth weight: A systematic review. *J Dev Behav Pediatr* 2011; **32**:678-687.

5. Hadders-Algra M. Developmental coordination disorder: Is clumsy motor behaviour caused by a lesion of the brain at early age? *Neural Plastic* 2003; **10**(1-2):39-50.

6. Wang T, Tseng M, Wilson BN. Functional Performance of children with developmental coordination disorder at home and at school. *Dev Med Child Neurol* 2009; **51**:817-825.

7. Flapper BC, Houwen S, Schoemaker MM. Fine motor skills and effects of methylphenidate in children with attention-deficit-hyperactivity disorder and developmental coordination disorder. *Dev Med Child Neurol* 2006; **48**(3):165-9.

8. Henderson SE, Sugden DA, Barnett AL. Manual Movement Assessment Battery for Children-2 Examiner's Manual. UK: Harcourt Assessment 2007.

9. Van Waelvelde H, De Weerdt W, De Cock P. Association between visual perceptual deficits and motor deficits in children with developmental coordination disorder. *Dev Med Child Neurol* 2004; **46**(10):661-6.

10. Tsai CL, Wu SK. Relationship of visual perceptual deficit and motor impairment in children with developmental coordination disorder. *Percep Motor Skills* 2008; **107**(2):457-72.

11. Piek JP, Dyck MJ, Francis M, et al. Working memory, processing speed and set-shifting in children with developmental coordination disorder and attention-deficit hyperactive disorder. *Developmental Medicine & Child Neurology* 2007; **49**:678-683.

12. Smits-Engelsman BCM, Bloem-van der Wel HE, Duysens J. Children with developmental coordination disorder respond similarly to age-matched controls in both speed and accuracy if goal-directed movements are made across the midline. *Child Care Health Dev* 2006;**32**(6):703-710.

13. Hyde C, Wilson P. Online motor control in children with developmental coordination disorder: chronometric analysis of double-step reaching performance. *Child Care Health Dev* 2010;**37**(1):111-122.

14. Volman MJM, Laroy ME, Jongmans MJ. Rhythmic coordination of hand and foot in children with developmental coordination disorder. *Child Care Health Dev* 2006; **32**(6):693-702.

15. Wilmut K, Wann JP, Brown JH. Problems in the coupling of eyes and hand in the sequential movements of children with developmental coordination disorder. *Child Care Health Dev* 2006; **32**(6):665-678.

16. Skinner RA, Piek JP. Psychosocial implications of poor motor coordination in children and adolescents. *Hum Mov Sci* 2001; **20**(1-2):73-94.

17. Kanioglou A, Tsorbatzondis H, Barkoukis, V. Socialization and behavioural problems of elementary school pupils with developmental coordination disorder. *Can J Occup Ther* 2005; **101**(1):163-173.

18. Pratt ML, Hill, EL. Anxiety profiles in children with and without developmental coordination

disorder. *Res Dev Disabil* 2011; **32**(4):1253-1259.

19. Zwicker JG, Harris SR, Klassen AF. Quality of life domains affected in children with developmental coordination disorder: A systematic review. *Child Care Health Dev* 2013; **39**(4):562-580.

20. Ferguson GD, Jelsma D, Jelsma J, et al. The efficacy of two task-orientated interventions for children with Developmental Coordination Disorder: Neuromotor task training and Nintendo Wii Fit training. *Res Dev Disabil* 2013; **34**: 2449-2461.

21. Cohen J. Statistical power analysis for the behavioral sciences (2nd ed.) Hillsdale. 1988.

22. Vuijk PJ, Hartman E, Scherder E, et al. Motor performance of children with mild intellectual disabilities and borderline intellectual functioning. *J Intellect Disabil Res* 2010; **54**(11):955-965.

23. Liu T, Breslin CM. Fine and gross motor performance of the Movement ABC-2 by children with autism spectrum disorders. *Res Autism Spectr Disord* 2013; **7**:1244-1249.

24. Dewey D, Cantell M, Crawford SG. Motor and gestural performance in children with Autism Spectrum Disorder, Developmental Coordination Disorder and/or Attention Deficit Hyperactive Disorder. *J Int Neuropsychol Soc* 2007; **13**(2):246-256.

25. Dziuk MA, Gidley-Larson JC, Apostu A, et al. Dyspraxia in autism: association with motor, social and communicative deficits. *Dev Med Child Neurol* 2007; **49**(10):734-739.

26. Fournier KA, Hass CJ, Naik SK, et al. Motor coordination in Autism Spectrum Disorders: A synthesis and meta-analysis. *J Autism Dev Disord* 2010; **40**(10): 1227-1240.

27. Rodger S, Ziviani J, Watter P, et al. Motor and functional skills of children with developmental coordination disorder: A pilot investigation of measurement issues. *Hum Mov Sci* 2003; **22**(4-5): 461-478.

28. Prunty M, Barnett AL, Wilmut K, et al. Visual perceptual and handwriting skills in children with developmental coordination disorder. *Hum Mov Sci* 2016; **49**:54-65.

29. Mombarg R, Jelsma D, Hartman E. Effect of Wii-intervention on balance of children with poor motor performance. *Res Dev Disabil* 2013; **34**:2996-3003.

30. Jelsma D, Geuze RH, Momburg R. et al. The impact of Wii Fit intervention on dynamic balance control in children with probable developmental coordination disorder and balance problems. *Hum Mov Sci* 2014; **33**:404-418.

31. Farhat F, Hsairi I, Baati H, et al. The effect of a motor skills training program in the improvement of practiced and non-practiced tasks performance in children with Developmental Coordination Disorder. *Hum Mov Sci* 2016; **46**:10-22.

32. Shamsul AS, Mohd Rohaizat H, Muholan K, Noor Zaiha H, Ang WC, Sei FS, Zulfadli MH, Nurul Husna AR, Azimatun Noor A, Rozita H, Nazarudin S. Quality of life and its influencing factors among physically disabled teenagers in Kuala Lumpur, Malaysia. *Malaysian Journal of Public Health Medicine 2013*; 13 (2):11-19.