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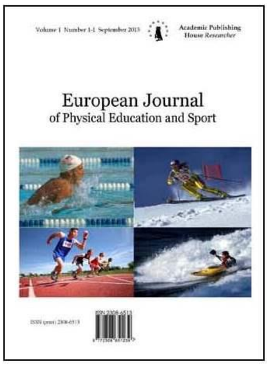

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Static Balance Ability in Children with Developmental Coordination Disorder

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Abstract

The aim of the current study was the examination of disorders in motor coordination of 8/9-year-old school aged children and the detection of possible differences in balance performance between those children assessed with Developmental Coordination Disorder (DCD) and matched peers. It was found that 20 children out of the total number of 200 participating in this study, exhibited definite motor difficulties indicating a DCD disorder.The 20 students diagnosed with DCD were matched one by one with typically developing children participated in a detailed study of balance control. The main finding of the present study was the ability to control balance in both Anterior Posterior (A/P) and Medio Lateral (M/L) directions was inferior in students with DCD than in typically developing children. The findings reinforce the need for the evaluation of balance performance in school-aged children, in order specific individual motor profiles to be established for optimizing and adapting appropriate intervention programs.

Keywords: posture, motor performance, motor difficulties, stability, DCD.

1. Introduction

A minimal level of competence in motor skills, ranging from fine coordination to gross motor coordination and balance skills, is necessary to participate in daily physical activities typical of young children. However, while some children execute a whole range of motor tasks easily, others experience considerable difficulties coordinating and controlling their body movements. The latter children are often diagnosed with Developmental Coordination Disorder (DCD) which has been described as one of the six most commonly occurring developmental disorders (Kwan, Cairney, Hay & Faught, 2013).

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DCD refers to a chronic neuro-developmental condition and is characterized by a marked impairment in the performance of motor skills, with a significant negative impact on the performance of activities of daily living (APA, 2013). The estimated prevalence ranges from 1.8 % to 20 % (Lingam, Hunt, Golding, Jongmans, and Emond, 2009) with the most frequently percentage quoted in literature being 5 % to 6 % (Gaines, Missiuna, Egan & McLean, 2008) for the school aged population.

The core aspects of the disorder include difficulties in learning new motor skills and sensorimotor coordination deficits (Geuze, 2005). Among the many sensorimotor problems found in children with DCD, poor postural control is the most common, demonstrated in 73–87 % of the DCD-affected population (Macnab, Miller, & Polatajko, 2001). Static balance refers to the ability to maintain an upright posture and to keep the centre of gravity within the limits of support (Nashner, Shupert, Horak & Black, 1989).

Children without static balance control lack the stabilizing framework that is necessary to develop normal functional activities. Since the development of the balance control is the base for development of all other skills, the ability to maintain postural stability in children with DCD is an important area that needs to be addressed. The problem requires special attention because any impairment in balance ability may increase the risk of falls, limit activity participation, and affect motor skill development (Fong, Lee & Pang, 2011; Grove & Lazarus, 2007).

However, there is increasing evidence that children with DCD often withdraw from physical activity opportunities as a consequence of their movement incompetence (Bouffard, Watkinson, Thompson, Dunn, and Romanow, 1996) and they are significantly less likely than their peers to participate in organized and free play activities (Cairney et al., 2005, Cairney, Hay, Veldhuizen, Missiuna & Faught, 2010). At early ages, skill deficits may be less noticeable as the movement demands of play are low. However, skill demands increase with age and children with motor difficulties fall further behind (Wall, 2004). The result is that low participation delays skill development which in turn increases withdrawal from active play (Cairney et al., 2010). Thus, early identification of poor activity and participation is essential to promote successful transition and integration into the elementary school setting (Wong, 2002).

The attainment of motor skills is a continuous challenge for children (Geuze, 2007), particularly for those whose coordination is not developing in a typical form. A basic motor action might represent a troublesome task rather than play and fun for these children, who gradually tend to withdraw from tasks that include motor coordination demands. Since the effects of DCD appear to be so far reaching and the early years of life are such an important period of growth opportunity (Anderson, Shinn, Fullilove et al., 2003), it is important to emphasize early identification and intervention of young children suspected as, or at risk of, having DCD.

Children with probable DCD have an increased risk of wide-ranging difficulties outside the motor domain (Lingam et al., 2010). Thus, early identification can lead to education, guidance and encouragement of children to engage in typical childhood activities and hence decrease the risk of reduced self-esteem, self-efficacy and social participation (Missiuna, Rivard, and Bartlett, 2003). Therefore, because motor development of children with DCD is generally slower than that of typically developing children and presumably this is also true for balance skills, it was considered crucial for a better understanding of their motor characteristics to examine the possible difference in static balance between children with and without DCD.

2. Methods

2.1. Participants

The children who participated in this study were sampled from various elementary schools in Thessaloniki, a big town of Northern Greece. There were 200 children (104 boys and 96 girls) 8-9 years old (mean age 8.43±1.85 months). All children were tested using the tasks from the quantitative test of neuromuscular coordination of the whole body (Body Coordination Test for Children BCTC*;* Körperkoordinationstest für Kinder, KTK) (Kiphard and Schilling, 2007, 1974). It was found that 20 children (13 boys and 7 girls) out of the total number of 200 children participating in this study exhibited definite motor difficulties indicating a DCD disorder. The 20 students diagnosed with DCD were matched one by one with typically developing children according to gender, age, school placement and socioeconomic characteristics, minimizing in this way the risk of different environmental and educational influences.

All children had normal-range IQs and no evidence of physical or neurological disorder. Children with a history of prenatal problems, neurological diseases, sensory disturbances, premature children and children with epilepsy or other chronic diseases were excluded from the study. Additionally, information such as motor skill delays and poor coordination interfere with the performance of self-care activities and academic achievement beyond what would be anticipated, given their age and intellectual ability was derived from children's school records and parent's reports according to APA's (2000) recommendations.

All parents or legal guardians provided written informed consent prior to participation approved by an Institutional Review Board for use of Human subjects, allowing children's involvement in the program and access to relevant information.

Testing procedures and instrumentation

Body Coordination Test for Children (BCTC; Körperkoordinationstest für Kinder, KTK, Kiphard & Schilling, 1974).

Actual motor competence of the 200 students from the initial sample was measured by the Body Coordination Test for Children (BCTC; Körperkoordinationstest für Kinder, KTK, Kiphard & Schilling, 1974), which is designed to evaluate the overall body co-ordination and control of children from 5 to 14.11 years old. It is appropriate for children with typical development, as well as for children with developmental disabilities. This test measures the overall body coordination and control of children, through the measurement of four tasks: balance during walking backwards, obstacle jump on one foot, sideways movements with initial position and side jumps right-left of two trials, during which the children had to jump from side to side over a little beam with both feet together, as often as possible within a period of 15 seconds. The instructions provided at each participant were the same for everyone in order to avoid influence from internal or external motivation.

For each of the four items, a raw score (RW) and a scaled score (Motor Quotient score) are recorded. A total Motor Quotient (MQ=100±15) percentiles, and motor age can be estimated per item as well as for the global test. A score less than 85 in MQ indicates a serious co-ordination disturbance (Schilling & Kiphard, 1974). Internal consistency reliability based on test-retest reliability coefficients, for each item, ranges from .80 to .96. Data collection took approximately 20 minutes to complete for each child.

Balance testing

All balance tests were performed on an EPS pressure platform (Loran Engineering S.r.I., Bologna – Italy). The system uses 2304 force sensing resistors in an active area of 70x50 cm to record plantar pressure at 25Hz. All the participants performed one-leg stance (OLS) with opened eyes and double-leg stance (DLS) with opened and closed eyes. During the DLS, the children were instructed to stand erect, as motionless as possible, on a normal comfortable posture, with opened eyes looking straight ahead at a cross marked at approximately eye level on a black board three meters away and barefoot with feet shoulder width apart on the platform with the arms by their sides. Each child was requested to keep a quiet stance posture for 30 seconds. The assessment included three measurements, and a five-minute rest was provided between successive trials. The best trial was further analyzed (Ageberg, Roberts, Holmström, and Fridén, 2003). The participants performed the same task with closed eyes. During OLS, the participants were instructed to stand on their dominant foot, which was placed pointing straight forward in relation to reference lines in the frontal and sagittal planes. The dominant leg was defined by asking the children to kick a ball five times (Hopper, Allison, Fernandes, O'Sullivan & Wharton, 1998).

The swinging leg was flexed 90° at the hip and knee joints with both arms hanging relaxed at the sides (Ageberg et al., 2003). The subjects were instructed to stand as still as possible, looking straight ahead at a point on the wall 65 cm away. The test order between legs was randomized. Data recording started once the subject was stable in the required posture. Ample time was provided for familiarization. If OLS balance was not maintained for ten seconds, the trial was not recorded and the measurement was repeated. A computer program (Footchecker 3.2, Engineering S.r.I., Bologna-Italy) was used to compute peak-to-peak amplitude (CoPmax) and standard deviation of the COP from the mean value of COP in antero-posterior (SDy) and mediolateral (SDx) axis in mm, often defined as sway amplitude. Students executed the test by standing on the platform in a normal position with the hands next to the thighs and the feet slightly apart. The first test included the Normal Quite Stance for 30 seconds and the second test the OLS for 10 seconds. The COP sway area used in the data analysis was the average from three successful trials for each participant in each test condition. The larger the COP sway area was, the more the body swayed and the worse the standing balance was.

Statistical Analysis

For the statistical data analysis the statistical package SPSS 20 was used. All data are presented as means ± SD. The performance on balance tasks (DLS with open and closed eyes, and OLS) was examined using Independent sample t-tests. The level of significance was set at $p<0.05$.

3. Results

The independent sample t-test revealed that in M/L direction, CoPmax (t=5.32, p=.000) and CoPsd (t=3.65, p=.001) in double leg stance (DLS) with eyes open were significantly greater in children with DCD comparing to children with typical development. In the same task with the eyes closed, there was also statistically significant difference in both CoPmax (t=3.91, p=.001) and CoPsd (t=2.58, p=.016). Additionally, statistically significant difference in A/P direction was also noticed between the 2 groups in DLS with eyes open [(t=2.85, p=.007), (t=3.24, p=.002)] and eyes closed [(t=4.94, p=.000), (t=3.24, p=.004)] in CoPmax and CoPsd, respectively.

As regards to one leg stance (OLS) task on dominant foot, the Independent sample t-test revealed a statistically significant difference between the groups in CoPmax (t=4.14, p=.000) and CoPsd (t=8.11, p=.000) in M/L direction as well as in CoPmax (t=3.27, p=.003) and CoPsd in A/P direction. The means and SD values of balance tasks, Peak-to-peak amplitude of the center of pressure (CoP) displacement (CoPmax) and standard deviation of the CoP (CoPsd) in the Anterior Posterior (A/P) and in Mediolateral (M/L) direction in 3 balance tasks for the children with DCD and typically developing children are represented in table 1.

Table 1. Peak-to-peak amplitude of the center of pressure (CoP) displacement (CoPmax) and standard deviation of the CoP (CoPsd) in the Anterior Posterior (A/P) and in Mediolateral (M/L) direction in 3 balance tasks for the 2 groups

	Students with DCD (n=20)	Typically Developing (n=20)
Double Leg Stance with opened eyes (mm)		
CoPmax -M/L	24.59 ±10.82	11.34 ±2.61*
CoPsd -M/L	5.60 ±2.06	3.78 ± .84*
CoPmax-A/P	18.02 ±6.88	13.36 ±2.42*
CoPsd-A/P	5.03 ±3.09	2.59 ±1.12*
Double Leg Stance with closed eyes (mm)		
CoPmax -M/L	22.49 ±10.99	12.51 ±3.09*
CoPsd -M/L	5.29 ±1.52	4.34 ± .64*
CoPmax-A/P	18.20 ±4.40	12.66 ±2.39*
CoPsd-A/P	4.24 ±2.72	2.21 ± .63*
One Leg Stance (mm)		
CoPmax -M/L	30.67 ±7.80	22.77 ±2.52*
CoPsd -M/L	11.98 ±2.92	6.11 ±1.39*
CoPmax-A/P	38.92 ±7.24	23.29 ±4.17*
CoPsd-A/P	8.18 ±1.93	6.52 ±1.19*

* p<*.05* pre to post

4. Discussion

The present study aimed to examine movement difficulties among typically developing elementary students in Greece and to examine the static balance ability between those children assessed with Developmental Coordination Disorder (DCD) and matched peers. The Body Coordination Test for Children (BCTC; Körperkoordinationstest für Kinder, KTK, Kiphard and Schilling, 1974) was chosen for the purposes of this study since it was considered an adequate test for the assessment of children's coordinative performance (Graf, Koch, Dordel *et al.*, 2004; Graf, Koch, Kretschmann-Kandel *et al.*, 2004). The results showed that 10 % of the children participating in this study exhibited motor difficulties indicating the existence of DCD disorder, a percentage that is similar to previous findings (dos Santos & Vieira, 2013; Tsiotra, Flouris, Koutedakis et al., 2006).

Fundamental motor skills are still improving in developing children. To avoid the variability of postural control and balance in younger children, the age band selected for this study was between 8 and 9 years of age, when static balance control reaches adult levels for open-eye conditions (Taguchi and Tada, 1988) and becomes steadier (Wolff, Rose, Jones, Bloch, Oehlert & Gamble, 1998). The main finding of the present study was that the ability to control balance in both Anterior Posterior (A/P) and Medio Lateral (M/L) directions, so far static balance is described by the CoP excursions, was inferior in students with DCD.

The reduction of children's with DCD ability to maintain balance has been well documented. In agreement with previous studies (Cherng, Hsu, Chen & Chen, 2007; Inder and Sullivan, 2005; Tsai, Wu & Huang, 2008), the results of the present study demonstrated that participants with DCD display greater CoP displacement than their typically developing counterparts (Table 1). This result reflects less efficient control of balance in all 3 conditions with increasing difficulty that were examined.

An absence of differences between children with and without DCD on sway measures when standing with two legs, either with eyes open or closed, was found in recent studies (Geuze, 2003; Przysucha & Taylor, 2004). However, in the present study, students with DCD demonstrated significantly larger sways similarly with recent reports (Inder & Sullivan, 2005; Tsai et al., 2008). Remarkably, although participants with DCD had significantly larger sway compared to typically developing counterparts in both two leg stance conditions, there was not larger CoP displacements in both groups when performed the DLS task blindfolded (Table 1). These observation maybe explained by the fact that the momentary absence of vision, in both students with and without DCD, resulted in greater reliance on proprioceptors, rather than on visual afferent inputs in maintaining balance control.

Poor balance control may indicate a cerebellar impairment. The cerebellum is essential for the fine motor control of movement and posture and its dysfunction may dislocate balance control. Balance is supposed to be one of the most autonomously controlled tasks in the motor domain. It has been suggested that the picture emerges is that non-optimal cerebellar function affects the development of autonomous control of balance and contributes to the problems that children with DCD have (Geuze, 2003).

An interesting review by Wilson & McKenzie (1998) using meta-analysis noted that children with DCD were inferior on most measures of information processing, including visual-spatial processing, kinaesthetic perception, and cross-modal sensory integration which integrates two or three different sensory inputs. This finding suggests that the poor motor performance of children with DCD could result from both a deficit in the individual sensory systems as well as a deficit in sensory organization. Although the studies under review focused on fine motor performance, the implication of the finding could potentially generalize to standing balance. However, since one of the diagnostic criteria for DCD is that no known medical problems can explain the motor coordination disorder, it is unlikely that the balance difficulty in the children with DCD was due to a deficit in the individual sensory system.

No matter what is the proper explanation for balance difficulties in children with DCD, the fact is that they have reduced performance in all balance tasks that were examined. Since DCD is known to have immediate adverse effects on children's day-to-day functioning (both academic and daily living skills) and significantly impacts on academic, psycho-social and vocational outcomes (American Psychiatric Association, 2000), studying balance abilities of young children as they develop throughout their school years emerges as a very important issue.

Children with DCD judge themselves to be less competent than their peers, both physically, psychologically and socially (Cairney et al., 2005), and are likely to avoid participating in physical activities in order to avoid experiencing failure and sustaining injuries due to their difficulty in balance control. Thus, early identification and treatment of children with balance control difficulties like those in DCD children may help lighten such restrictions. More studies using larger samples and conducted in different school education regions are needed to ascertain motor profiles and balance performance of Greek elementary school children before appropriate intervention programs are applied to deal with DCD occurrence and its negative consequences.

References:

Ageberg, E., Roberts, D., Holmström, E., & Fridén, T. (2003). Balance in single-limb stance in healthy subjects and the effect of short-duration sub-maximal cycling. *BMC Musculoskelet Disorders*, *4,* 14.

American Psychiatric Association (2013). *Diagnostic and Statistical Manual of Mental Disorders: DSM-5*. American Psychiatric Publishing Inc, Arlington, VA, USA.

American Psychiatric Association. (2000). *Diagnostic*: reliability of testing procedure *and statistical manual of mental disorders (4th text revision)*. Washington, DC: American Psychiatric Association.

Anderson, L.M., Shinn, C., Fullilove, M.T., Scrimshaw, S.C., Fielding, J.E., Normand, J., et al. (2003). The effectiveness of early childhood development programs: A systematic review. *American Journal of Preventive Medicine*, *24*(3S), 32–46.

Bouffard, M., Watkinson, E.J., Thompson, L.P., Dunn, J.L.C., & Romanow, S.K.E. (1996). A test of the activity deficit hypothesis with children with movement difficulties. *Adapted Physical Activity Quarterly, 13,* 61-73.

Cairney, J., Hay, J., Flouris, A., Mandigo, J., & Faught, B. (2005). Developmental Coordination Disorder, self-efficacy toward physical activity and play: Does gender matter? *Adapted Physical Activity Quarterly, 22*, 67–82.

Cairney, J., Hay, J.A., Veldhuizen, S., Missiuna, C., & Faught, B.E. (2010). Developmental coordination disorder, sex and activity deficit over time: a longitudinal analysis of participation trajectories in children with and without coordination difficulties. *Developmental Medicine and Child Neurology*, *52*, 67-72.

Cherng, R. J., Hsu, Y. W., Chen, Y. J., & Chen, J. Y. (2007). Standing balance of children with developmental coordination disorder under altered sensory conditions. *Human movement science*, *26*(6), 913-926.

dos Santos, V.A.P., & Vieira, J.L.l. (2013). Prevalence of developmental coordination disorder in children aged 7 to 10 years. *Revista Brasileira de Cineantropometria e Desempenho Humano, 15,* 2, 233-242.

Fong, S. S. M., Lee, V. Y. L., & Pang, M. Y. C. (2011). Sensory organization of balance control in children with developmental coordination disorder. *Research in Developmental Disabilities, 32*, 2376–2382.

Gaines, R., Missiuna, C., Egan, M., & McLean, J. (2008). Educational outreach and collaborative care enhances physician's perceived knowledge about Developmental Coordination Disorder. *BMC Health Services Research, 8*(1), 21.

Geuze, R. H. (2007). Characteristics of DCD: On problems and prognosis. In R. H. Geuze (Ed.), *Developmental coordination disorder: A review of current approaches* (pp. 9–25). Marseille, France: Solal.

Geuze, R.H. (2005). Postural control in children with developmental coordination disorder. *Neural Plasticity 12*, 183–196.

Graf, C, Koch, B., Dordel, S., Schindler-Marlow, S., Icks, A., Schüller, A., Bjarnason-Wehrens, B., Tokarski, W., & Predel, H.G. (2004). Physical activity, leisure habits and obesity in first-grade children. *European Journal of Cardiovascular Prevention and Rehabilitation 11,* 284-290.

Graf, C., Koch, B., Kretschmann-Kandel, E., Falkowski, G., Christ, H., Coburger, S., Lehmacher, W., Bjarnason-Wehrens, B., Platen, P., Tokarski, W., Predel, H.G., & Dordel, S. (2004). Correlation between BMI, leisure habits and motor abilities in childhood (CHILT-Project). *International Journal of Obesity 28,* 22-26.

Grove, C. R., & Lazarus, J. A. C. (2007). Impaired re-weighting of sensory feedback for maintenance of postural control in children with developmental coordination disorder. *Human Movement Science*, *26*, 457–476.

Hopper, D., Allison, G., Fernandes, N., O'Sullivan, L., & Wharton, A. (1998). Reliability of the peroneal latency in normal ankles. *Clinical Orthopaedics and Related Research, 350*, 159–165.

Inder, J. M., & Sullivan, S. J. (2005). Motor and postural response profiles of four children with developmental coordination disorder. *Pediatric Physical Therapy, 17,* 18–29.

Kiphard, E.J., & Schilling, F. (1974). *Körper Koordinationstest für Kinder.* Weinheim. Beltz Test GmbH. Weinheim, Germany.

Kiphard, E.J., & Schilling, F. (2007). *Körper koordination test für Kinder.* Überbearbeitete und ergänzte Auflage. Beltz Test GmbH: Gottingen. Germany.

Kwan, M.Y., Cairney, J., Hay, J.A., & Faught, B.E. (2013). Understanding physical activity and motivations for children with developmental coordination disorder: an investigation using the theory of planned behavior. *Research in Developmental Disabilities*, *34*(11), 3691-3698.

Lingam, R., Golding, J., Jongmans, M., Hunt, L., Ellis, M., & Emond, A. (2010). The association between developmental coordination disorder and other developmental traits. *Pediatrics, 126*, e1109-1118.

Macnab, J. J., Miller, L. T., & Polatajko, H. J. (2001). The search of subtypes of DCD: Is cluster analysis the answer? *Human Movement Science, 20*, 49–72.

Missiuna, C., Rivard, L., & Bartlett, D. (2003). Early identification and risk management of children with developmental coordination disorder. *Pediatric Physical Therapy*, *15*, 32–38.

Nashner, L.M., Shupert, C.L., Horak, F.B., & Black, F.O. (1989). Organization of posture controls. An analysis of sensory and mechanical constraints. *Progress in Brain Research 80,* 411–418.

Przysucha, E. P., & Taylor, M. J. (2004). Control of stance and developmental coordination disorder: The role of visual information. *Adapted Physical Activity Quarterly, 21*, 19–33.

Taguchi, K., & Tada, C. (1988). Change of body sway with growth of children. In B. Amblard, A. Berthoz, & F. Clarac (Eds.), Posture and gait: Development, adaptation and modulation (pp. 59–65). Amsterdam: Elsevier.

Tsai, C. L., Wu, S. K., & Huang, C. H. (2008). Static balance in children with developmental coordination disorder. *Human movement science*, *27*(1), 142-153.

Tsiotra, G. D., Flouris, A. D., Koutedakis, Y., Faught, B. E., Nevill, A. M., Lane, A. M., & Skenteris, N. (2006). A comparison of developmental coordination disorder prevalence rates in Canadian and Greek children. *Journal of Adolescent Health*, *39*(1), 125-127.

Wall, T.A.E. (2004). The Third G Lawrence Rarick Memorial Lecture 2003. The developmental skill-learning gap hypothesis: implications for children with movement difficulties. *Adapted Physical Activity Quarterly*, *21* (3), 197–218.

Wilson, P. H., & McKenzie, B. E. (1998). Information processing deficits associated with developmental coordination disorder: A meta-analysis of research findings. *Journal of Child Psychology and Psychiatry, and Allied Disciplines, 39*, 829–840.

Wolff, D. R., Rose, J., Jones, V. K., Bloch, D. A., Oehlert, J. W., & Gamble, J. G. (1998). Postural balance measurements for children and adolescents. *Journal of Orthopedic Research*, 16, 271–275.

Wong, D. K. P. (2002). Struggling in the mainstream: The case of Hong Kong. *International Journal of Disability, Development and Education*, *49*, 79–94.