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Children with Developmental Coordination Disorder and Balance

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Abstract

The purpose of this study was to compare the postural sway profiles of 64 children with developmental coordination disorder with balance problems (DCD-BP) and 71 matched control children in the age range of 9-10 years. We measured the excursion of the center of pressure in conditions with and without vision while standing still on dominant, non-dominant, or two legs for 30 s. Area of sway, total path length, and Romberg's quotient were analyzed. The results showed there was significant difference between groups in almost every test except in two conditions of the area of sway, which children stood with vision on dominant leg and two legs. When standing with dominant or two legs, DCD-BP children demonstrated more total path length in all conditions and greater area of sway in conditions without visual information. DCD-BP children showed more difficulty standing on non-dominant leg with eyes closed or opened. Boys almost showed the same results. But, girls with DCD-BP only demonstrated significant difference in three conditions, when standing on two-leg stance with eye closed, dominant-leg stance with eye closed, and non-dominant-leg stance with eyes closed. Analysis of Romberg's coefficient also indicated that children with DCD-BP did not over-rely on visual information. Both groups had consistently larger RQ values (> 100%), indicating that eye closure provoked more postural sway than when balancing with sight.

Key words: developmental coordination disorder, static balance, visual information

Introduction

Motor control is the study of the neurophysiological factors that affect human movement (Payne & Isaacs, 2002). The study of motor control must include the study of action, perception, and cognition (Shumway-Cook & Woollacott, 2001). Understanding the control of action implies understanding the motor output from the nervous system to the body effector system, or muscles. This problem of coordinating many muscles and joints has been called the degrees-of-freedom problem (Bernstein, 1967). Perception is the integration of sensory impressions into psychologically meaningful information, and cognitive processes broadly to include attention, motivation, and emotional aspects of motor control that underlie the establishment of intent or goals (Shumway-Cook & Woollacott, 2001). For children with developmental coordination disorder (DCD), the strategy for regulating muscle activity is much less uniform and consistent. Jaric, Corcos, Agarwal, and Gottlieb (1993) suggested motor control strategies that involve regulation of antagonist muscle activity represent an advanced stage of motor learning and/or hierarchical motor development. Thus, the bilateral motor coordination deficits often observed in children with DCD may, in part, be a result of a less advanced motor control system and lack of capacity to organize and employ appropriate motor control strategies (Williams, 2002).

Balance is a somewhat ambiguous term used to describe the ability to maintain or move within a weight-bearing posture without falling. Balance can further be broken into three aspects: steadiness, symmetry, and dynamic stability. Steadiness refers to the ability to maintain a given posture with minimal extraneous movement (sway) and the term symmetry is used to describe equal weight distribution between the weight-bearing components (e.g., the feet in a standing position) (Nichols, 1997). Balance is often defined as static or dynamic. Static balance refers to the ability of the body to maintain equilibrium in a stationary position. Balancing on one foot, standing on a balance board, and performing a stick balance are common means of assessing static balance abilities (Gallahue &.Ozmun, 2002).

Research on the static balance abilities of normal children shows a linear trend toward improved performance from age 2 through 18 (DeOreo, 1971; Geuze, 2003; Hytonen, Pyykko, Aalto, & Starck, 1993; Keogh, 1965; Van Slooten, 1973; Wolff et al., 1998). Values for postural away measured from 5-6 years old to 15-18 years old subjects with eyes closed decreased with age to an extent equal to or greater than values recorded for subjects with eyes open (Wolff et al., 1998). Clear-cut boy-girl differences are not as apparent in static balance performance tasks as they are with other motor performance tasks. Girls tend to be more proficient than boys until about age 7 or 8, whereupon the boys catch up. Both sexes level off in performance around age 8, prior to a surge in abilities from age 9 to age 12 (DeOreo, 1980). Taguchi and Tada (1988) found the amplitude of sway during quiet stance decreased with age during 2 to 14 years of age. They also discovered spontaneous sway in children reaches adult levels by 9 to 12 years of age for eye-open conditions. Some studies also reported that the duration of single-limb stance increased steadily between the ages of 6 and 8 years (Figura, Cama, Capranica, Guidetti, & Pulejo, 1991; Riach & Hayes, 1987) in young children, to near-adult levels by the age of 7 years (Sutherland, Olshen, Cooper, & Woo, 1980; Wolff et al., 1998).

Motor development, which may be studied as a process or as a product, is continuous change in motor behavior throughout the life cycle. Children of normal intelligence and physical functioning tend to advance through the process of maturation, but many individuals, adults as well as children, fail to get beyond a normal progressive stage in many patterns of movement owing to known or unknown disease. Although growth is not as rapid during childhood as it is during infancy, they are still marked by steady increases in height, weight, and muscle mass. The period from the sixth through the tenth years of childhood is typified by slow but steady increases in height and weight and progress toward greater organization of sensory and motor systems. This period of slow growth gives the child time to get used to his or her body and is an important factor in the typically dramatic improvement seen in coordination and motor control during the childhood years (Gallahue &.Ozmun, 2002).

Coordination, which is linked to the motor fitness components of balance, speed, and agility, is the ability to integrate separate motor systems with varying sensory modalities into efficient patterns of movement. The more complicated the movement tasks, the greater the level of coordination necessary for efficient performance (Gallahue &.Ozmun, 2002). Gross body coordination, eye-hand, and eye-foot coordination appear to improve with age in a roughly linear fashion. Boys tend to exhibit better coordination than girls through childhood (Frederick, 1977; Van Slooten, 1973). Some studies showed that there are subgroups of children with DCD and poor static balance (Hoare, 1994; Macnab, Miller, & Polatajko, 2001). Children with DCD, even in the same age, form a heterogeneous group that may have different function deficit. Some children with DCD show worse in manual skills, but may be proficient in balance abilities, and vice versa. Wann, Mon-Williams, and Rushton (1998) found children with DCD displayed significantly greater standing sway than age-matched controls while standing upright on a static floor with eye-closed. Geuze (2003) also found children with DCD and balance problems showed more active control as evident from the center of pressure (COP) results, especially the case in the more difficult conditions of one-leg stance and eye closed. But it was not a problem when standing on two legs with eye open or eye closed. Przysucha and Taylor (2004) found boys with DCD and balance control difficulties did not demonstrate significant difference when standing with two legs and with eye open or eye closed. But when the sway values of children standing with eye open and eye closed were averaged, children with DCD and balance control difficulties demonstrated more anterior-posterior sway and greater area of sway. Unexpectedly, these two studies found that there was no main effect of vision in the children with DCD and balance problems.

The instrument, Movement Assessment Battery for Children (Henderson & Sugden, 1992), is divided into four age bands, 4-6, 7-8, 9-10, and 11-12 years old. Each age band includes three movement testing categories, manual dexterity, ball skill, and static and dynamic balance. Child located in different age band of Movement ABC is screened with different movement items. Until now, only a few studies explored the difference of static balance between children with and without DCD (Geuze, 2003; Przysucha & Taylor, 2004). All children compared in these studies covered four age bands and were not compartmentalized into two sexual groups. For limiting homogenous factors of growth and sex, as well as keeping the consistency of movement testing items of Movement ABC test, we choose children with and without DCD located at the same age band, nine and ten-year-old, to find the difference of static balance ability. We also separated two different sexual groups to explore this discrepancy respectively. Simultaneously, for a clearer understanding of control problems of children with DCD, children with DCD were restricted to the subgroup of balance problems.

Method

Subjects

Two hundred and seventeen children were recruited from regular classroom settings in Kaohsiung City, Taiwan with the assistance of principals and teachers. The sampling design was stratified random. The sample was limited to nine and ten-year-old children, 106 boys and 111 girls, in order to maximize its size and homogeneity. All of children were in the absence of emotional and behavioral problems, overt neurological disorders, and reduced IQ. In total 217 children received a letter to take home with information on the research project and an invitation to participate. All parents and children gave their written informed consent.

For the purpose of exploring the correlation between Movement ABC static balance score and the duration of standing on the force-plate on one leg with eyes open, all of students were tested on force-plate and categorized with the performance section of age band 3, nine and ten years, of Movement ABC test. These two tests were held in separate day in order to avoid child’s fatigue. The testing took approximately 75 minutes per participant. Scores on the Movement ABC test provided information on each participant’s overall motor skill level, as well as their balance control abilities. The Total Impairment Score (TIS) reflects a combined score for manual dexterity, ball skills, and static and dynamic balance ability, whereas the Total Balance Score (TBS) only describes the performance of the child on static and dynamic balance tasks. The selection criteria for the children with DCD and balance problems (DCD-BP) were

. TIS at or below the 5th percentile

. M-ABC balance subscore >2

. M-ABC static score >1

The selection criteria for the age-matched control were TIS above 15th percentile and M-ABC balance score≦3, that is, above the 15th percentile. The control children were individually matched with the DCD-BP children on age within a range of six months. The rigorous screening procedure (Geuze, 2003；Przysucha & Taylor, 2004) ensured that participants assigned to the group of interest had DCD as well as specific balance and static balance problems. By this method, the DCD-BP group compromised 30 boys and 34 girls, and the control group included 33 boys and 38 girls. These two groups differed significantly on both the TIS, t (133) = -14.329, $p < .001$, and the TBS, t (133) = -22.820, $p < .001$.

Apparatus

A Balance Performance Monitor (BMP) (SMS Healthcare, Elizabeth House, Elizabeth Way, Harlow, Essex CM19 5TL, UK) was used to objectively collect sway area and sway path on each foot or both feet. The equipment consists of the feedback unit and two movable footplates, which connect IBM compatible software and provide a permanent record of the child’s progress. The BMP display was positioned behind the child so the participant could not receive visual feedback during the test. The BMP sound was also turned off, so the participant could not receive any auditory biofeedback. Data were filtered low pass at 10.5 Hz and sampled at rate of .01 seconds (100Hz). The equipment provides sway displacement measures such as left-right weight distribution, postural sway, anterior-posterior weight distribution, sway area (mm^2), sway path (mm), and maximum sway speed (mms^{-1}). The BMP can provide a highly valid measure of sway measurement (r＝0.61-0.99) and show high and significant inter- and intra-tester reliability (ICCs ranging from 0.720 to 0.868) (Haas & Burden, 2000; Haas & Whitmarsh, 1998).

Procedure

The children’s height, weight, foot length and width (left and right), Movement ABC test scores were taken prior to the static balance testing. A week after they were screened with the M-ABC, children entered a quiet environment where they completed individual balance testing. Sway area and sway path were recorded during epochs of 30 s in two conditions, eye open and eye closed, both during two-leg and one-leg stance (Wolff et al., 1998). Sway area indicates the range and size of the area created during the center of pressure (COP) migration, and sway path typifies the amount of COP displacement. During two-leg stance, each child was assessed three times while standing with one foot with one each of the footplates, which were kept a uniform distance apart, without any postural correction. The participant was asked to stand as still as possible on a force plate and stood in a comfortable position, with arms relaxed at their side and feet positioned to shoulder width (Sackley & Baguley, 1993; Wolff et al., 1998). With one-leg stance, the dominant leg and non-dominant leg were also tested three times. The dominant leg was defined by asking the children to kick a ball and then to indicate which was their dominant ball-kicking leg (Hopper, Allison, Fernandes, O'Sullivan, & Wharton, 1998). During one-leg stance, a stork posture was adopted with their arms by their side. The children were told not to fear falling while an assistant always stood behind the child to catch if the child tended to fall. During the static balance tasks with eyes open, the child was asked to stare at a red light-dot positioned at 2 meters away at eye height. In the condition of one-leg stance with eye closed, the children started off with eyes open and when they felt in balance they say "yes" and closed their eyes, upon which the measurement was started. During the measurement, children's eyes were observed. If not kept closed eyes, the child was reminded and the test was repeated until three successful trials were made in the one-leg stance conditions. Testing of the subjects with eyes open was performed first. Standardized verbal cues of encouragement were given to each participant. The process was repeated after an enough rest period for collecting eighteen successive trials. The testing session of each participant lasted approximately 30 minutes. A series of independent sample t tests was carried out at .05 alpha level to eliminate the impact of morphological differences on balance control status. There were no significant differences between the DCD-BP and control groups in foot length, t (133) = -.370, p＝.712, foot width, t (133) = -.380, p＝.705, and body height, t (133) = -1.520, p＝.131.

Data Analysis

All subjects had successful eighteen trials, which separately contain three tasks of dominant-leg, non-dominant leg, and two-leg stance with eyes open or closed. All of measurement units, millimeter and square millimeter, were converted into centimeter and square centimeter respectively. Mean values for every condition were calculated. Two measures, sway area and sway path, were analyzed. The correlation between M-ABC static balance score and the duration of standing on the force-plate on one leg with eyes open was analyzed with Person Product-Moment Correlation. All two variables were translated into Romberg's coefficient, that is the COP measure in a condition without vision divided by the COP measure with vision, to determine whether (a) the balance control of both groups was affected when visual information was removed, and (b) this effect was proportionally similar for both groups

(Przysucha & Taylor, 2004). If the Romberg coefficient is larger than 100%, it means more sway condition with eyes closed than eyes open. The larger the deviation from 100%, the more pronounced the effect of removing vision on balance performance during stance (Elliot, FitzGerald, & Murray, 1998; FitzGerald, Murray, Elliott, & Birchall, 1994).

Values for results are expressed as means and standard errors where applicable. Statistical comparisons were made by two-way multivariate analysis of variance (MANOVA). Measurements in static balance on force-plate between children with and without DCD were compared by the Student's *t* test. Two-tailed p values of less than .05 were considered significant.

Results

Movement ABC performance on the static balance item was one of the criteria in the selection procedure of the DCD-BP group. The measure of static balance in the age band 3, 9 and 10-year-old, of movement ABC is duration of standing with one leg on balance board. The correlation between two Movement ABC static balance scores, number of seconds and impairment scores converted by original seconds, and the duration of standing on the force-plate on one leg with eyes open was explored. For achieving statistic power, 217 students were tested on force-plate and Movement ABC test. Table 1 presented no correlation between the Movement ABC static balance scores, no matter with number of seconds and impairment scores, and the time in balance on force-plate when standing on one leg with eyes open.

Table 1

Correlation between the forceplate and movement ABC when standing with eye open

	Dominant leg		Non-dominant leg	
	time	Impairment score	time	Impairment score
Sway area	-.236	.178	-.258	.175
Sway path	-.257	.221	-.290	.123

There were significant difference between children with and without DCD, but there were no difference both on the sexes and on the interaction between sex and DCD (see Table 2). A significant main effect of sway was found between the whole children groups and between boys group in almost all conditions except two-leg and dominant-leg stance with eyes open (see Table 3 and 4). But, girls with DCD-BP only demonstrated significant difference in three conditions, when standing on two-leg stance with eye closed (F(1,70)＝5.674, p＝0.015 in sway area; F(1,70)＝5.58, p＝0.007 in sway area), dominant-leg stance with eye closed (F(1,70)＝0.91, p＝0.036 in sway path), and non-dominant-leg stance with eyes closed (F(1,70)＝7.40, p＝0.021 in sway area) (see Table 5). All of DCD-BP groups were found to have larger sway path and sway area. All of groups showed increased stability with eyes open compared with eyes closed. Although dominant legs of children with or without DCD-BP showed more increased stability than their non-dominant legs, the significant “dominant limb by gender” effect was not obtained in any group. The balance abilities of girls with DCD-BP were better than those of boys, and significantly different on four items, two-leg with eye closed (F＝8.455, p＝.044 in sway area; F＝3.940, p＝.025 in sway path), dominant-leg with eye open (F＝0.097, p＝.023 in sway path), and non-dominant-leg with eyes open (F＝3.681, p＝.023 in sway path). The balance abilities of girls without DCD-BP were better than those of boys, and significantly different only on two items, two-leg with eye closed (F＝16.615, p＝.010 in sway area; F＝3.614, p＝.018 in sway path).

Table 2

The Wilks’ Lambda values of multivariate Tests

	value	F	Error df	Sig
DCD	.765	1.941	114	.019*
Sex	.811	1.477	114	.111
DCD×Sex	.910	.630	114	.870

* p<.05

Table 3

Means and standard errors of static balance with and without vision for all of children with and without DCD based on sway area (cm^2) and sway path (cm)

	DCD-BP (n=64)		Normal (n=71)	
Conditions	Sway area	Sway path	Sway area	Sway path
Two-leg, eyes open	1.80(0.20)	23.67(1.19)*	1.36 (0.16)	20.84(0.60)*
Two-leg, eyes closed	2.53(0.33)*	30.47(1.10)*	1.65(0.17)*	25.95(0.76)*
Dominant-leg, eyes open	2.23(0.18)	32.00(1.47)*	1.78(0.23)	26.95(1.49)*
Dominant-leg, eyes closed	5.55(0.53)*	57.92(2.97)*	3.50(0.35)*	43.96(2.26)*
Nondominant-leg, eyes open	2.86(0.25)*	37.13(1.72)*	1.91(0.16)*	29.74(1.20)*
Nondominant-leg, eyes closed	6.64(0.58)*	61.07(3.08)*	4.47(0.32)*	50.59(2.13)*

Standard errors are in parentheses.

* p<.05

Table 4

Means and standard errors of static balance with and without vision for boys with and without DCD based on sway area (cm^2) and sway path (cm)

	DCD-BP (n=30)		Normal (n=33)	
Conditions	Sway area	Sway path	Sway area	Sway path
Two-leg, eyes open	2.13(0.33)	25.55(1.26)*	1.42 (0.18)	22.02(0.84)*
Two-leg, eyes closed	3.27(0.63)	33.06(1.86)*	2.13(0.31)	27.85(1.28)*
Dominant-leg, eyes open	2.52(0.30)	35.52(2.23)*	1.81(0.27)	27.16(1.87)*
Dominant-leg, eyes closed	6.65(0.98)*	64.03(4.78)*	3.68(0.50)*	45.56(3.35)*
Non-dominant-leg, eyes open	3.34(0.48)*	41.24(2.91)*	1.94(0.23)*	30.66(1.60)*
Non-dominant-leg, eyes closed	7.45(1.00)*	66.81(4.99)*	4.76(0.53)*	51.72(3.50)*

Standard errors are in parentheses.

* p<.05

Table 5

Means and standard errors of static balance with and without vision for girls with and without DCD based on sway area (cm^2) and sway path (cm)

	DCD-BP (n=34)		Normal (n=38)	
Conditions	Sway area	Sway path	Sway area	Sway path
Two-leg, eyes open	1.51(0.25)	22.01(1.93)	1.32 (0.25)	19.81(0.82)
Two-leg, eyes closed	1.87(0.23)*	28.17(1.14)*	1.22(0.12)*	24.30(0.80)*
Dominant-leg, eyes open	1.97(0.21)	28.89(1.81)	1.76(0.37)	26.76(2.30)
Dominant-leg, eyes closed	4.57(0.43)	52.53(3.49)*	3.34(0.50)	42.58(3.09)*
Non-dominant-leg, eyes open	2.44(0.19)	33.50(1.79)	1.88(0.22)	28.94(1.77)
Non-dominant-leg, eyes closed	5.93(0.62)*	56.00(3.62)	4.21(0.38)*	49.60(2.59)

Standard errors are in parentheses.

* p<.05

Both groups, no matter in boys' or girls', consistently reflected an increased Romberg coefficients values (> 100%), indicating that eye closure provoked more postural sway than when balance with sight. But, any of Romberg coefficients revealed no significant differences between DCD-BP and normal groups.

Table 6

Means and standard errors of Romberg coefficients (eye closed/ eyes open × 100%) based on sway area and sway path for children with and without DCD

	DCD-BP		Normal	
	boys	girls	boys	girls
Two-leg, sway area	156.47(12.26)	159.02(20.10)	174.04(22.67)	126.48(10.13)
Two-leg, sway path	130.23(3.80)	137.88(6.09)	128.48(4.99)	125.67(3.70)

Dominant-leg, sway area	292.36(33.05)	283.57(28.58)	249.21(29.28)	274.21(36.15)
Dominant-leg, sway path	182.97(11.39)	185.96(8.48)	180.21(15.42)	172.40(11.98)
Non-dominant-leg, sway area	264.11(27.99)	254.18(25.17)	285.71(32.02)	308.57(48.75)
Non-dominant-leg, sway path	169.75(10.46)	172.12(9.70)	172.51(10.24)	187.60(12.18)

Standard errors are in parentheses.

* p<.05

Discussion

Although cross-cultural differences between Asia and Western countries were found on a number of the test items of Movement ABC, some researchers found this test content was suitable for use with Hong Kong Chinese children (Chow, Henderson, & Barnett, 2001). In purely practical terms of our study, we found the test satisfactory in that Taiwan children appeared to enjoy participating, and none of the items proved difficult to administer. Children in Asia countries, Hong Kong and Japan, performed better on the item of static balance than American children, especially significantly different on the dynamic balance section (Chow et al., 2001; Miyahara et al., 1998). Reported prevalences around Asia countries vary but are not disparate: Singapore, 14.1% on nine-year-old children (Wright & Sugden, 1996) and Japan, 15.6% on nine and ten-year-old children (Miyahara et al., 1998). In this article, the prevalence figure of 34.1% was much higher in Taiwan, 26.5% and 42.3% on nine-year-old and ten-year-old children respectively.

Since children, from 2 to 10 years of age, show linear maturation and are still marked by steady morphological appearance, such as height, weight, or muscle mass (Gallahue &.Ozmun, 2002), they belonged to inequable groups. When up to 10 years of age, adolescent growth spurts again. Simultaneously, children, from age 2 through 12, static balance ability also shows a linear trend toward improved performance with two-leg stance (DeOreo, 1971; Geuze, 2003; Keogh, 1965; Hytonen et al., 1993; Van Slooten, 1973; Wolff et al., 1998), even with single-leg stance (Figura, et al., 1991; Riach & Hayes, 1987). By 9 to 12 years of age, during quiet stance, children reach adult levels for eye-open conditions (Taguchi & Tada, 1988). So, for limiting heterogeneous factors on growth and static balance ability, in our study, children’s age was limited between 9 and 10 years of age. It made the different result from some studies which the ranges of participants’ age were between 6 and 12 (Geuze, 2003) and between 6 and 13 (Przysucha & Taylor, 2004). Some underlying factors maybe counteracted the effects of static balance abilities between DCD-BP and normal groups.

Motor control difficulties of children labeled as having DCD, even in the same age band, are quite diverse. Children with DCD form a heterogeneous group that may have different function deficit. When compared balance abilities between DCD and normal cohorts, some studies had either not appraised children’s balance at all or covered children with and without balance problems in the same DCD group (Jung-Potter et al., 2002; Wann et al., 1998), but our study had scrupulously included a well-marked measure of balance control in the screening protocol like some researches (Geuze, 2003; Przysucha & Taylor, 2004).

Human standing posture is stabilized by constant regulation of the complex neuromuscular system. Normal persons stand upright by making only very small excursions controlled by proprioception. Since Romberg’s test in 1853, the analysis of postural sway during upright stance has been used as a tool in evaluating a person’s ability to balance and in evaluating disorders of the nervous system (Jeong, 1994). Although the lack of differences between children with and without DCD-BP on sway measures when standing with two legs, no matter with eye open or eye closed, was found in recent studies (Geuze, 2003; Przysucha & Taylor, 2004), however, in our study, children with DCD-BP significantly had larger maximum COP excursion values, especially with eye closed.

Methods of measurement of standing posture can be classified into three areas: measurement of body segment displacement during standing posture, measurement of muscle activity responsible for the maintenance of posture, and measurement of the movement of the center of pressure (Hasan, Lichtenstein, & Shiavi, 1990). Sway area in posturography describes the size and shape of the ground covered by the center of pressure as well as the proportion of the functional base of support used during sway (Hasan et al., 1990). Sway path, which describes the overall amount of COP migration, has been found to (a) be a primary indicator of balance control status and (b) provide the greatest sensitivity for detecting differences in body sway (FitzGerald et al., 1994; Jeong, 1994). The reliability of these two measures has been verified in past researches involving individuals with and without balance control difficulties (Benvenuti et al., 1999; Geurts, Nienhuis, & Mulder, 1993). In Przysucha and Taylor’s study (2004), the sway path was more consistent than the sway area during the analysis of interclass correlations.

Huh, Williams, and Burke (1998) has reported an interesting laterality effect in children with DCD. They found movement times of the right limb to a far target were slower than those for the left limb of children with DCD. In contrast for control children, movement times and underlying neuromuscular parameters of limb movements to both near and far targets were similar for right and left limbs. Since left hemisphere dysfunction has been associated with deficiencies in selected temporal aspects of skilled unimanual movements (Geuze & Kalverboer, 1994), a potential left-hemisphere dysfunction in some children with DCD could manifest itself in the observed slower right hand movements involved in more complex aiming tasks. If it did, this condition might happen on legs. But this phenomenon seems not to happen to this study. The dominant leg, almost all of children preferred to choose right legs to kick ball, of Children with DCD-BP did not show significantly different than the non-dominant leg. So, a simple task, such as one-leg stance on stable force-plate, should not be a problem big enough to compare the dominant and the non-dominant legs of children with DCD.

Although boys tend to exhibit better coordination than girls through childhood (Frederick, 1977; Van Slooten, 1973) and clear-cut boy-girl differences are not as apparent in static balance performance tasks as they are with other motor performance tasks (DeOreo, 1980), the boys' static balance abilities seem not to be more proficient than girls' in this study. We found the static balance abilities, on two-leg and one-leg stances, of girls with DCD were much better than those of boys with DCD, but girls without DCD only showed significantly better than boys without DCD on two-leg stance with eyes closed.

Geuze (2003) found there was no correlation between the Movement ABC total score and the time in balance and when standing on one leg with eyes open. For evaluating the correlation of “static balance” abilities between one-board balance on Movement ABC and one-leg stance on force plate, all of scores, 217 children's duration on these two items, were recorded and compared. We also found no correlation between them. During standing with one leg on balance board, the child must conquer a swing base and keep the board from tilting. Although the child could use their arms to balance if necessary, the action is much more difficult when compared with one-leg stance on flat force plate.

The components of the nervous system which plays a major role in the maintenance of static balance are visual input, vestibular mechanisms, and proprioceptive and kinesthetic reflex activities (Dornan, Fernie, & Holliday, 1978). Coordinated accurate movements are supported by proprioceptive feedback mechanisms which come into play to correct externally or internally induced errors in position, velocity, and force of movement (Nashner, Shumway-Cook, & Marin, 1983). Children with DCD could be less able to recognize when they approach their threshold of balance or were poor at correcting posture. Children with DCD may be behind their peers in acquiring the skill of integrating vestibular and proprioceptive information.

Motor coordination probably also contributes to the increase in strength (Blimkie, 1993), so one of factors to influence their balance exhibition should be the duration when standing on force plate. Although some studies found children with DCD-BP had no significant problems during two-leg stance (Geuze, 2003; Przysucha & Taylor, 2004), they showed significantly difference when standing for a longer while in this study. One of factors to influence the result may be that children with DCD would fatigue easily. Because the movement patterns of these children are inefficient, higher fitness levels may be required to perform simple tasks that others take for granted (Ward, 1994). As a consequence, children with DCD can fatigue much earlier than better coordinated children in that their inefficient movement pattern and mechanical inefficiency can involve high-energy demands.

The Romberg's coefficient may provide a simple clinical description of the degree of dependence upon visual input in the maintenance of balance. Children with DCD-BP seem not to over-rely on visual information as some researches (Geuze, 2003; Przysucha & Taylor, 2004). This viewpoint is a little different from other study. Wann et al. (1998) propose that, in general, children with DCD tend to show a strong reliance on vision in maintaining balance and suggest that children with DCD are slow in developing the capacity to process proprioceptive input and to effectively integrate visual and proprioceptive information. But, again, this simple task seems not to be a big problem to process these information.

From this study, when limited children's age band, 9 and 10 year-old, we found the static balance abilities of children with DCD-BP showed significantly worse than those of children without DCD. This condition was manifest on stance with eyes closed, but we also found children with DCD-BP did not over-rely on visual information.

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