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Activity participation intensity is associated with skeletal development in pre-pubertal children with developmental coordination disorder

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ABSTRACT

Purpose: This study aimed (1) to compare the skeletal maturity and activity participation pattern between children with and without developmental coordination disorder (DCD); and (2) to determine whether activity participation pattern was associated with the skeletal development among children with DCD.
Materials and methods: Thirty-three children with DCD (mean age: 7.76 years) and 30 typically developing children (mean age: 7.60 years) were recruited. Skeletal maturity was assessed with the Sunlight BonAge system. Motor ability was evaluated by the Movement assessment battery for Children-2 (MABC-2). Participation patterns were evaluated using the Children Assessment of Participation and Enjoyment assessment. Analysis of variance was used to compare the outcome variables between the two groups. Multiple regression analysis was performed to examine the relationship between skeletal development, motor performance and activity participation intensity in children with DCD.
Results: The DCD group had significantly delayed skeletal development, lower MABC-2 derived scores, and participated less intensely in various types of physical activities than their typically developing peers. After accounting for the effects of age and sex, activity participation intensity score remained significantly associated with delay in skeletal development, explaining 28.0% of the variance ($F_{change1,\ 29} = 11.341$, $p = 0.002$).
Conclusion: Skeletal development is delayed in pre-pubertal children with DCD. Limited activity participation intensity appears to be one of the contributing factors.

1. Introduction

Developmental coordination disorder (DCD) is a well-known motor-based problem that affects approximately 6% of children at primary school age (American Psychiatric Association, 2000). Due to their poor motor proficiency, DCD-affected children participate in fewer activities and less intensely than their typically developing peers (Fong, Lee, Chan, et al., 2011; Fong, Lee, & Pang, 2011; Jarus, Lourie-Gelberg, Engel-Yeger, & Bart, 2011). It is well known that participation in activities, particularly weight-bearing activities (e.g. soccer training), during pre-pubertal and pubertal periods is very important because external forces acting on the bones during different activities can facilitate bone growth and development (Rogol, Clark, & Roemmich, 2000; Vicente-Rodriguez, 2006). Sedentary life style in children with DCD may have a negative impact on skeletal development.

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Apart from bone strength, bone age is another useful parameter to indicate skeletal maturity. Traditionally, bone age is determined by the appearance of centres of ossification, fusion or non-fusion of epiphyses, and changes in size and shape of the wrist and hand bones (Cardoso, 2007). It is considered as the most valid biological measure of maturity (De Luca & Baron, 1999). Measurement of bone age is commonly used in clinical evaluation of growth and maturity status and is an important part of the diagnosis and management of paediatric growth disorders (Baxter-Jones, Thompson, & Malina, 2002). Previous studies have shown that bone age is positively associated with bone mass in preadolescent females (aged 8–13 years) (Ilich et al., 1996) and bone mineral density in children (aged 9–16 years) (Jones & Ma, 2005).

To date, no study has reported the skeletal maturity status and its relationship with activity participation in the DCD population. Therefore, the objectives of this study were (1) to compare the bone age, and activity participation pattern between children with and without DCD; and (2) to determine whether activity participation pattern is associated with the skeletal development among children with DCD.

2. Materials and methods

All sample size calculations were based on a statistical power of 0.80 and an alpha level of 0.05 (two-tailed). A previous study (Fong, Lee, & Pang, 2011) showed that the physical activity intensity score, as assessed by the Children's Assessment of Participation and Enjoyment (CAPE), was 108.37 (28.67) and 133.76 (26.61) for the DCD group ($n = 81$) and control group ($n = 67$) respectively, which translates into a large effect size of 0.92. Therefore, the minimum sample size needed to detect a significant between-group difference in the activity participation outcomes would be 20 for each group (alpha = 0.05, power = 0.80) (objective 1). Regarding the association between bone development and activity participation (objective 2), a previous study by Lehtonen-Veromaa et al. (2000) reported that in their multiple regression analysis, physical activity and other relevant variables combined to account for 54.7% and 63.4% of the variance in BMD of the femoral neck and lumbar spine, respectively, among peripubertal girls. Therefore, a large effect size ($R^2 = 0.4$, translating into $F^2 = 0.67$) was estimated for this study. A minimum sample size of 24 children with DCD was required to detect a significant association of activity participation intensity with skeletal development, after accounting for age, sex, and motor function (alpha = 0.05, power = 0.8, total number of predictors = 4).

Children with DCD were recruited from local Child Assessment Centres by convenience sampling. Inclusion criteria were (1) a formal diagnosis of DCD that was made by an interdisciplinary team (paediatrician, clinical psychologist, physiotherapist and occupational therapist) at the Child Assessment Centre according to criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) (American Psychiatric Association, 2000); (2) 6–10 years old; (3) study in a regular education framework; (4) no intellectual disability; and (5) of Chinese ethnicity. Exclusion criteria were (1) diagnosis of emotional, endocrine, neurological, or other movement disorders; or (2) significant musculoskeletal, cardiopulmonary or medical conditions that may influence motor performance or skeletal development. Chinese children with normal development were recruited from the community on a volunteer basis as controls. The inclusion and exclusion criteria for the control group were same as the DCD group except that they did not have any history of DCD.

This study was approved by the human subjects ethics review subcommittee of the Hong Kong Polytechnic University. After explaining the study to each participant and their parents, written informed consent was obtained. Data were collected by an experienced paediatric physiotherapist in the Balance and Neural Control Laboratory of the Hong Kong Polytechnic University. All procedures were conducted in accordance with the Declaration of Helsinki.

Basic demographic information including sexual maturity (as indicated by the presence of pubic hair, onset of breast development and testicle volume in cubic centimeter) was obtained by interviewing the children and their parents. If the participants were not sure about the testicle volume, parents were invited to measure it with their boys in a closed room. The volume of water displaced by the testicles was documented. Skeletal development was determined ultrasonically with the 'Sunlight BonAge system' (Sunlight Medical Ltd., Tel Aviv, Israel). This device provides an accurate (intra-operator precision: 0.24 years for males and 0.25 years for females), radiation free assessment of skeletal age (chronological age: 5–18 years old) and the results are highly correlated with the conventional Greulich and Pyle method (Mentzel et al., 2005; Sunlight Medical Ltd., 2005). Each participant was asked to rest the left forearm on the BoneAge measurement table and position the distal tip of the left ulna styloid process between the two ultrasound transducers. Ultrasonic waves with a frequency of 750 kHz were transmitted through the left wrist. Five to eleven cycles of measurement were performed to ensure high precision. The BonAge device calculated the speed of sound (velocity of the ultrasound wave increases when ultrasound is transmitted through ossified epiphyses in relatively matured radius and ulna) and used the distance between the two transducers under known and controlled pressure conditions, and a proprietary sex- and ethnicity-based algorithm to provide a numeric result of 'bone age' that was used for subsequent analysis (Mentzel et al., 2005; Sunlight Medical Ltd., 2005). In addition, 'delay in skeletal development' was calculated from the equation: chronological age − bone age.

The Movement assessment battery for Children-2 (MABC-2) was used to measure the fine and gross motor performances in all participants. It is a standardized tool for measuring motor performance in 3- to 16-year-old children and consists of eight tasks for each of the three age ranges. The eight tasks are categorized into three domains: manual dexterity, aiming and catching, and balance. Test items in the three domains are described in Henderson, Sugden, and Barnett (2007). The raw score of each item was converted into the item standard score, and the component score, standard score, and percentile of each domain were derived from the item standard scores. Additionally, the total test score, standard score, and percentile rank were derived. The total test score (reflects the general motor proficiency), manual dexterity component score, aiming and catching component