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Balance in children with attention deficit hyperactivity disorder-combined type

Hsun-Ying Mao [a], Li-Chieh Kuo [b], Ai-Lun Yang [c], Chia-Ting Su [d,*]

[a] Department of Physical Medicine & Rehabilitation, National Taiwan University Hospital Hsin-Chu Branch, Hsinchu, Taiwan
[b] Department of Occupational Therapy, College of Medicine, National Cheng Kung University, Tainan, Taiwan
[c] Graduate Institute of Exercise Science, University of Taipei, Taipei, Taiwan
[d] Department of Occupational Therapy, College of Medicine, Fu Jen Catholic University, New Taipei City, Taiwan

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ABSTRACT

The balance ability in children with attention deficit hyperactivity disorder-combined type (ADHD-C) has not been fully examined, particularly dynamic sitting balance. Moreover, the findings of some published studies are contradictory. We examined the static and dynamic sitting balance ability in 20 children with ADHD-C (mean age: 9 years 3 months; 18 boys, 2 girls) and 20 age-, sex-, height-, weight-, and IQ-matched healthy and typically developing controls (mean age: 9 years 2 months; 18 boys, 2 girls). The balance subtests of the Movement Assessment Battery for Children (MABC) and the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) were used to compare the two groups, and a mechanical horseback riding test was recorded using a motion-capture system. Compared with the controls, children with ADHD-C had less-consistent patterns of movement, more deviation of movement area, and less-effective balance strategies during mechanical horseback riding. In addition, their performance on the balance subtests of the MABC and BOTMP were not as well as those of the controls. Our findings suggest that balance ability skill levels in children with ADHD-C were generally not as high as those of the controls in various aspects, including static and dynamic balance.

1. Introduction

Attention deficit hyperactivity disorder (ADHD) is one of the most common disorders in school-age children; the worldwide-pooled prevalence is 5.29% (Polanczyk, de Lima, Horta, Biederman, & Rohde, 2007). Some researchers have paid attention to the balance ability in children with ADHD (Piek, Pitcher, & Hay, 1999; Raberger & Wimmer, 2003; Schlee, Neubert, Worenz, & Milani, 2012; Tseng, Henderson, Chow, & Yao, 2004). Adequate balance ability is important for many daily activities (Larkin & Hoare, 1992). Insufficient balance ability negatively affects not only children's motor performance but also the psychosocial aspect of their life (Shum & Pang, 2009; Simeonsson et al., 2003). Some studies (Piek et al., 1999; Shum & Pang, 2009; Tseng et al., 2004) on children with ADHD-combined type (ADHD-C) report that their balance is significantly less proficient than that of matched controls without ADHD, but this finding was not consistent with other reports (Pitcher, Piek, & Hay, 2003).

* Corresponding author at: Department of Occupational Therapy, College of Medicine, Fu Jen Catholic University, 510 Zhongzheng Road, Xinzhuang Dist., New Taipei City 24205, Taiwan. Tel.: +886 2 2905 2091; fax: +886 2 2904 6743.
E-mail addresses: chiatingsu@gmail.com, 078566@mail.fju.edu.tw (C.-T. Su).

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1.1. ADHD and balance ability

Piek et al. (1999) used the Movement Assessment Battery for Children (MABC) to assess motor performance in 16 children with ADHD-predominantly inattentive type (ADHD-PI), 16 children with ADHD-C, and a group of 16 age- and verbal-IQ-matched children without ADHD (controls). Their results showed that children with ADHD-PI "had significantly poorer fine motor skills. . . [and that those] with ADHD-C had significantly greater difficulty with gross motor skill" than did the controls. Consistently, Tseng et al. (2004) found that children with ADHD-C demonstrated poorer balance as measured by the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP). However, in another MABC-based study on balance in 104 boys with ADHD and 39 controls without (Pitcher et al., 2003), they found no significant differences in the static and dynamic balance subtest results. Thus, the question of balance ability in children with ADHD-C is still open.

1.2. ADHD and dynamic balance ability

Although the MABC and BOTMP balance subtests can tell us something about balance performance, they are less informative about dynamic balance performance and balance strategies (Hatzitaki, Zisi, Kollias, & Kioumourtzoglou, 2002). In daily life, dynamic balance ability is required for many tasks (Shumway-Cook & Woollacott, 2007). Because few studies have investigated dynamic balance in children with ADHD, we used a (dynamic) mechanical horse and a motion analysis system in our study.

1.3. Purposes of this study

The aim of our study was to examine the static and dynamic balance ability of children with ADHD-C. To our knowledge, this was the first study measuring dynamic balance ability in children with ADHD by using the objective motion analysis and mechanic horse. We hypothesized that children with ADHD-C would have static and dynamic balance performance levels that differed significantly from those of children without ADHD.

2. Methods

2.1. Participants

Forty children (age range: 6 years 8 months–12 years 4 months) were recruited from elementary schools in southern Taiwan. Twenty of them, 18 boys and 2 girls (mean age: 9 years 3 months [SD: 1 year 4 months]; age range: 7 years 7 months–12 years 4 months), were diagnosed with ADHD-C by child psychiatrists using the criteria from the Diagnostic and Statistical Manual of Mental Disorders-4th edition (DSM-IV; American Psychiatric Association, 1994). The 20 controls, 18 boys and 2 girls, were between 6 years 10 months and 11 years 4 months (mean age: 9 years 2 months [SD: 1 year 2 months]). There were no significant differences in age, height, or weight between the two groups. All participants met the age-equivalent score on the Similarities and Vocabulary subtests of the Wechsler Intelligence Scale for Children, 3rd edition (WISC-III). These two subtests were chosen because the combination of their results was viewed as one of the best indicators for general cognitive ability (Sattler, 1992). The manual muscle test (MMT) was used to screen out children with abnormal muscle strength that might affect the balance measurements; all the recruited children met the level of good or normal strength. To confirm the grouping, a parental questionnaire to screen children with ADHD, Conners' Parent Rating Scale-Revised Short Form, was used to assess all of the participants. The results supported the diagnosis of ADHD for each child in the ADHD group, and indicated that none of the controls had the symptoms of ADHD.

2.2. Instruments

2.2.1. Qualisys motion capture system

The motion capture system (ProReflex-MCU 240; Qualisys Medical AB, Gothenburg, Sweden) used was a passive optoelectronic kinematic analyzer with infrared cameras, a personal computer, and software. The camera unit used reflected infrared light to detect the position of each retro-reflective marker worn by participants. The motion data were captured at a sampling rate of 100 Hz. A digital Butterworth filter with a cutoff frequency of 10 Hz was used to eliminate high-frequency noise. Forty-five retro-reflective markers 20-mm in diameter were attached at different body landmarks (Fig. 1) to estimate the movement of participant's center of mass (COM). Three markers were set on the mechanical horse (one on the front and two on the rear) to provide a base when analyzing the motion during horseback riding. During data collection, a trial that contained four complete cycles (i.e., four repetitions of motion) was considered sufficient for analysis. Three parameters of balance were drawn from the collected data: (1) consistency of COM deviation in the four cycles: the more consistent the COM movement between cycles, the more stable the balance strategy; (2) deviation of COM area ratio: the ratio of the difference between the COM movement area of the horse and participant to the COM movement area of the horse (i.e., the absolute value of [COM movement of horse area − COM movement of participant area]/[COM movement of horse area]): the larger the ratio, the less skilled the participant's ability to adjust body movement based on how the mechanical horse moves; and (3) the largest COM differences in medial–lateral (ML) and anterior–posterior (AP) directions during movement, which is the largest length in the M–L and A–P minus the smallest length in