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Contributions of trunk muscles to anticipatory postural control in children with and without developmental coordination disorder

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Current evidence suggests that movement quality is impacted by postural adjustments made in advance of planned movement. The trunk inevitably plays a key role in these adjustments, by creating a stable foundation for limb movement. The purpose of this study was to examine anticipatory trunk muscle activity during functional tasks in children with and without developmental coordination disorder (DCD). Eleven children with DCD (age 7 to 14 years) and 11 age-matched, typically-developing children performed three tasks: kicking a ball, climbing stairs, and single leg balance. Surface electromyography (EMG) was used to examine the neuromuscular activity of bilateral transversus abdominis/internal oblique, external oblique and L3/4 erector spinae, as well as the right tibialis anterior and rectus femoris muscles. Onset latencies for each muscle were calculated relative to the onset of rectus femoris activity. In comparison to the children with DCD, the typically-developing children demonstrated earlier onsets for right tibialis anterior, bilateral external oblique, and right transversus abdominis/internal oblique muscles. These results suggest that anticipatory postural adjustments may be associated with movement problems in children with DCD, and that timing of both proximal and distal muscles should be considered when designing intervention programs for children with DCD.

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1. Introduction

Children with developmental coordination disorder (DCD; American Psychiatric Association, 2000) are at risk of pervasive, long-term difficulties associated with various aspects of neuromuscular activation and postural control. Problems with anticipatory postural adjustments (APAs) in this population of children have been identified during upper extremity pointing (Huh, Williams, & Burke, 1998; Johnston, Burns, Brauer, & Richardson, 2002), precision grasping (Jucaite, Fernell, Forssberg, & Hadders-Algra, 2003), and fine motor tasks (Smits-Engelsman, Wilson, Westenberg, & Duysens, 2003). Altered reactive postural adjustments (RPAs), difficulty in processing sensory inputs, and inconsistent and inefficient neuromuscular activation sequences, timing, and force production (Geuze, 2003; Lundy-Ekman, Ivry, Keele, & Woollacott, 1991; Piek & Skinner, 1999; Raynor, 2001; Volman, Laroy, & Jongmans, 2006; Williams, 2002; Williams & Woollacott, 1997) may also contribute to postural control problems.

Typically-developing children integrate movement and posture so effortlessly that the underlying control processes are not generally considered. This complex synthesis is ensured by the interplay of two central strategies that are designed to minimize the effects of equilibrium disturbances: APAs, which involve prediction of upcoming perturbations, and RPAs, which are based on sensory feedback received after perturbations occur (Massion, Alexandrov, & Frolov, 2004). APAs are particularly important, as they support a state of postural readiness, contribute to force generation necessary for movement, and enable efficient recovery from perturbations (Ledebt, Bril, & Brenière, 1998; Patla, 2003). As such, altered use of anticipatory strategies is likely to impair the performance of daily activities requiring postural control.

1.1. Anticipatory trunk muscle activation and postural control

By its central location in the body, the trunk is optimally situated to support distal limb segment mobility, providing a stable base for movement tasks such as reaching or walking (Forssberg, 1999; Massion et al., 2004), and facilitating force generation and transfer to more distal segments during coordinated multi-joint movement (Anderson & Behm, 2005; Hodges, 2003; Kibler, Press, & Sciascia, 2006; Massion et al., 2004). Although the passive structure of the spine (i.e., that created by the bones and ligaments) contributes to its ability to resist compression and shearing forces, coordinated spinal muscular activity ultimately determines the stability of those joints (Gardner-Morse & Stokes, 1998; McGill, Grenier, Kavcic, & Cholewicki, 2003; Panjabi, 1992).

Stability (or stiffness) of the spine is partially dependent on the dynamic co-contraction of numerous synergist and antagonist muscles, in order to limit excessive joint motion while allowing generation of the necessary torques and desired movement (Gardner-Morse & Stokes, 1998; Hodges, 2003; Lee, Rogers, & Granata, 2006; McGill et al., 2003). In general, all trunk muscles are thought to contribute equally to the stability of that region (Cholewicki, Panjabi, & Khachatryan, 1997; Cholewicki & VanVliet, 2002; McGill, 2002; McGill et al., 2003); therefore, depending on the task, modest levels of abdominal and extensor muscle co-contraction are sufficient to ensure stability (Cholewicki et al., 1997; Kavcic, Grenier, & McGill, 2004; McGill et al., 2003). In addition, accurate control of the spine depends on central prediction of the anticipated and temporal demands of stability (Hodges, 2003; Hodges & Richardson, 1997). Thus, the role of anticipatory trunk muscle activity has become the subject of much study and discussion, in an attempt to describe the optimal determinants of stability for movement and musculoskeletal function (e.g., Hodges, 2003; Kibler et al., 2006; McGill et al., 2003).

To date, most of this research has focused on adult populations. As such, little is known about the developmental aspects of anticipatory trunk muscle activation or the muscles' impact on coordinated movement in individuals with neurodevelopmental disabilities such as DCD. For children with DCD, for whom postural control processes may not function optimally, a better understanding of trunk muscle function may have important implications for both assessment and intervention.

1.2. Postural control and neuromuscular activation in children with DCD

Altered anticipatory and reactive neuromuscular activation involving both the trunk and the extremities may interfere with the initiation and execution of coordinated movement, helping to ex-