A detailed examination of the physiological and cognitive mechanisms of handwriting difficulties in children with Developmental Coordination Disorder: the role of attention, fatigue and joint hyper-mobility

Key findings

1. **Eye tracking**: revealed that the DCD group rarely revisited their text after writing it which indicates that much of their attentional resources are focused on the production and execution of handwriting.

2. **Electromyography**: revealed fatigue in the Opponens Brevis muscle and Extensor Carpi Radialis Brevis but not First Dorsal Interosseous during the two minute copy fast task.

3. **Joint Mobility**:
   a. The typically developing group were more hyper-extended than the DCD group in two of the four joints showing significant group effects.
   b. Flexion and not extension was more related to handwriting performance in children with DCD.

4. **Hand Strength**: No significant differences between children with and without DCD on palmar, pinch or tripod grips.

5. **Pen Pressure**: The DCD group exerted less pressure than their TD peers while writing.

Project aims

This project examined three main research questions.

1. Are long writing pauses in the handwriting of children with DCD related to cognitive processes specifically the planning and revision of content?
2. Are long writing pauses in the handwriting of children with DCD related to fatigue of the writing arm while writing?
3. Is there a relationship between joint mobility, hand strength and handwriting performance in children with DCD?

Background

Handwriting difficulties are prevalent in children with Developmental Coordination Disorder (DCD) (APA, 2013) and are a significant source of referrals to children’s occupational therapy. Research on handwriting difficulties in this group has found that they produce fewer words per minute compared to typically developing (TD) peers and they tend to pause within words while writing (Prunty et al, 2014; Figures 1 & 2) which is an indication of a lack of automaticity in the skill. Little is known about the impact of this pausing on their ability to engage in higher level writing processes such as planning and revising text (key to producing good writing). In addition, there is a lack of research on factors that are assumed to underlie handwriting difficulties such as fatigue, joint laxity, hand strength and pen pressure.

Figure 1: 10 year old boy with DCD, many pauses (red circles) within words

Figure 2: 10 year old typically developing boy, pauses (red circles) occur between words
Methodology
51 children aged 8-15 years of age were recruited to take part in two studies (DCD= 20, TD=31). The children with DCD were recruited from the Handwriting Clinic database at Brunel University London. All children were assessed for DCD in line with the DSM-5 criteria.

Study 1 – Eye Behaviour During Writing
- **Handwriting Task:** The 10 minute free-writing task from the Detailed Assessment of Speed of Handwriting (DASH; Barnett et al., 2007)
- **Eye & Pen Movements:** The participants wrote with a stylus on an LCD writing tablet which records the movement of the pen during handwriting. Eye-tracking technology was used to capture cognitive and attentional data during the handwriting tasks.

Study 2 – The Role of Fatigue, Grip-Strength, Joint Laxity & Pen Pressure
- **Handwriting Task:** The 2 minute Copy Fast task from the Detailed Assessment of Speed of Handwriting (DASH; Barnett et al., 2007)
- **Pen Movements:** Participants completed the copy fast task from the DASH with an inking pen on paper placed on a digitizing writing tablet to record the movement of the pen.
- **Fatigue:** Electromyography (EMG) was used to measure muscle activation during the DASH copy fast task in the children with DCD.
- **Joint Laxity:** The range of motion (ROM) for active flexion and extension were assessed in the metacarpal phalangeal, proximal interphalangeal and distal interphalangeal joints of the hand in children with DCD and TD controls. A standard hand goniometer was used to measure ROM to the nearest degree.
- **Grip strength:** assessed using a dynamometer across three types of grips; power, pinch and tripod
- **Pen Pressure:** The writing tablet transmits information about the degree of pen pressure on the tablet surface as the pen moves across the surface.

Findings and recommendations
1. The eye movements of children with DCD indicate the labour demands of handwriting production in this group. Explicit teaching of the skill to this group is essential for their handwriting development.
2. Children with DCD may benefit from being taught strategies for revising text during writing.
3. There were no group differences in hand strength (pinch, tripod & palmar). Clinicians need to be cautious when considering poor muscle strength as a factor in the handwriting of children with DCD.
4. Extension in the joints of fingers and children with DCD exerting less pressure on the work surface did not correlate with handwriting performance. Clinicians need to be cautious when considering ‘joint mobility’ or pressure on pen as factors in poor handwriting performance.

Publications

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References