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Original article

Perceived task complexity of trunk stability exercises

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ABSTRACT

Background: Perceived task complexity can impact participation in an exercise programme and the level of skill acquisition resulting from participation. Although trunk stability exercises are commonly included in the management of people with low back pain, potential differences in perceived task complexity between those exercises have not been investigated previously.
Objective: To investigate the perceived task complexity following first time instruction of two common stability exercises: the abdominal brace and abdominal hollow.
Design: Cross-sectional.
Methods: Twenty-four naïve healthy participants received instruction in the performance of an abdominal brace and an abdominal hollow with feedback. Participants rated their perceived task complexity (*mental*, *physical*, and *temporal demand*, *performance*, *effort*, *frustration*) for each exercise on the NASA-Task Load Index.
Results: The abdominal hollow was associated with higher perceived *mental demand* than the abdominal brace ($p = 0.01$), and required more time to learn ($p < 0.01$). The abdominal brace was associated with greater *mental demand* and *frustration* when performed after the abdominal hollow than before.
Conclusions: This study has provided the first evidence for differences in perceived task complexity between two commonly used trunk stability exercises. Those differences in perceived task complexity may influence the selection of exercises intended to enhance the robustness of spinal stability.

Trunk stability exercises are widely used in the management of people with low back pain (LBP) (Liddle et al., 2009; Smith et al., 2014a) and in healthy populations to improve athletic performance (Frost et al., 2015). For exercise programmes designed for people with chronic LBP (Escolar-Reina et al., 2010) and other domains (*e.g.* weight loss programmes (Mata et al., 2010) and drug therapies Eisen et al., 1990; Stone, 2001) the more complex a treatment programme is perceived to be, the less likely people are to adhere to that programme. However, it has been argued that skill acquisition is enhanced through participation in complex training programmes that involve greater cognitive processing than less complex tasks (reviewed in Carey et al., 2005). It is clear that there are important implications for perceived task complexity in relation to rehabilitation programmes. However, whether there are differences in perceived task complexity between commonly used trunk stability exercises remained to be investigated.

A variety of exercises are used to improve the robustness of trunk stability (Hodges et al., 2013; McGill, 2014; Wells et al., 2014). One exercise is the abdominal brace which emphasizes a general co-contraction of trunk flexor and extensor muscles to increase spinal stiffness and maintain spinal orientation (McGill, 2014). Another is the abdominal hollow that intends to selectively contract specific trunk muscles that contribute to the control of spinal motion (Hodges et al., 2013; Richardson et al., 2004). Those exercises have been compared in terms of trunk muscle activity (Maeo et al., 2013), influence on trunk muscle coordination (Hall et al., 2009), spinal stability index scores (Grenier and McGill, 2007), ability to generate compressive loads on the lumbar spine (Grenier and McGill, 2007), and the ability to control spinal motion following sudden trunk perturbations (Vera-Garcia et al., 2007). Findings from these studies have been used to argue the advantages and limitations of either exercise in patient management, which is important given their implications for exercise programme design and prescription. For example, if the intention is to limit spinal motion to avoid symptom provocation and the additional compression applied to the spine as a result of co-contraction

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is not of immediate concern, then the abdominal brace could have an advantage over the abdominal hollow. However, if the goal is to control spinal motion, optimise the coordination of the trunk muscles while limiting the amount of compression on the spine then the abdominal hollow could have an advantage over the abdominal brace. Given that a variety of trunk stability exercises can improve symptoms related to LBP and function (Smith et al., 2014b), it is important to consider that there may be additional variables that could influence the selection of one exercise approach over the other. Just as it is important to understand the differences between those exercises in terms of spinal load and muscle activity, potential differences in perceived task complexity could influence the selection of one exercise over another in a given clinical circumstance.

Perceived task complexity is influenced by task characteristics and individual factors of the people who perform the task (Campbell, 1988). In exercise design, task characteristics include physical and temporal parameters: sets, repetitions, load, duration, frequency, rate, rhythm, and rest (Bird et al., 2005). Task characteristics can also include specific performance criteria; i.e. the ability to independently contract trunk muscles and maintain a normal respiratory pattern. Individual factors that influence perceived task complexity may include: cognitive ability (Robinson, 2001; Steele-Johnson et al., 2011), emotional state (Pourtois et al., 2013), life stress (Klein and Barnes, 1994), frustration (Libb, 1972), and expertise (Haerem and Rau, 2007). It is thought that the degree to which the individual can conceptualize the task based on previous motor learning, known as analysability, can influence perceived task complexity (Perrow, 1981). That dynamic combination of factors contributes to the overall perception of task complexity within an exercise.

The objective of this study was to investigate the perceived task complexity of two common trunk stability exercises, the abdominal brace and hollow. Consistent with clinical practice guidelines (Hodges et al., 2013) and previous research (Hall et al., 2009) using these two abdominal exercises, ultrasound imaging was used to provide feedback to participants on their performance of the abdominal hollow and not the abdominal brace. The abdominal hollow was performed to 5% maximum voluntary contraction (MVC) of the transversus abdominus/internal abdominal oblique (TrA/IAO) and the abdominal brace to 10% MVC of the external abdominal oblique (EAO) muscle. Given the additional control required to selectively contract specific abdominal muscles and the potential for a reduction in the analysability of the abdominal hollow, it was hypothesized that this approach would be perceived as more complex than the abdominal brace approach in each subcategory of the National Aeronautics and Space Administration – Task Load Index questionnaire (NASA-TLX) (Hart and Staveland, 1988). Given the possibility of differences in perceived complexity between exercise approaches, it was also hypothesized that perceived complexity of the abdominal brace would be greater when performed after the abdominal hollow. In addition, the influence of potential co-variates (intensity of abdominal muscle contraction, time to satisfy the performance criteria for the abdominal hollow and brace, and the participant's baseline physical activity) on the participant's perceived task complexity were investigated.

1. Methods

1.1. Participants

A convenience sample of twenty-four healthy participants (13 male, 11 female; age 20 ± 3 years; height 170.0 ± 8.3 cm; weight 61.5 ± 11.0 kg; 21 right, 3 left hand dominant) with no reported history of LBP and no reported previous experience with either of the exercises investigated were recruited for this study. All participants were recruited from the general university community, via general student/staff emails and study posters, between March and April 2014. The participants varied in physical activity levels with an average of 1729 (1328; range: 99–4918; mean category: moderate) metabolic equivalent task (MET) minutes per week, as determined by the International Physical Activity Questionnaire (IPAQ) (Kurtze et al., 2008). Prior to participation, all participants were given written and verbal information about the experimental procedure, and gave informed written consent. Participants were able to withdraw at any time without penalty. The Medical Research Ethics Committee approved all procedures.

1.2. Experimental procedure

Within one session, participants were instructed to perform a series of abdominal brace (McGill, 2014) and abdominal hollow (Richardson et al., 2004) exercises. All participants received a five-minute education session about trunk muscle anatomy, and an overview of each exercise approach. The participants were then positioned in crook-lying (knees in 90° of flexion, and feet flat on the bed shoulder width apart) for the abdominal hollow and semi-supine for the abdominal brace (both lower limbs resting on the plinth with one lower limb at 90° knee flexion and the other in full knee extension) (Hodges et al., 2013). Participants received specific instruction on the performance of each exercise in a counter-balanced order (n = 12 brace first, n = 12 hollow first). Verbal, tactile, ultrasound, and muscle activity (EMG) feedback was given during each approach consistent with clinical guidelines (Hodges et al., 2013; McGill, 2014; Richardson et al., 2004). For the abdominal brace, participants were asked to co-contract the abdominal and paraspinal muscles. For the abdominal hollow, participants were asked to draw the lower abdomen in toward the spine ('draw the umbilicus toward the spine' and 'draw the lower abdomen away from the waistband' were used as verbal cues). After a maximum of 10 min (Bjerkefors et al., 2010) or when the participant had completed the exercise in a manner consistent with pre-determined performance criteria (discussed in detail below), the participant was asked to complete the NASA-TLX (Hart and Staveland, 1988).

1.3. Electromyography

Right EAO and TrA)/IAO activity was recorded using bipolar Ag/AgCl surface electrodes (Blue Sensor N, Ambu, Denmark). The use of surface EMG electrodes has the limitation of potential "cross-talk" between the layers of the anterolateral abdominal wall. However, the electrode placement and orientation are consistent with previously published work (McGill et al., 1996) and sufficient to monitor abdominal muscle activity and provide feedback of contraction intensity (to the investigators) during the performance of each exercise. Skin was cleaned with an abrasive gel (Nuprep, D.O. Weaver & Co, USA) and alcohol. Electrodes were placed longitudinally, 20 mm apart, in alignment with the fibre orientation. EAO electrodes were placed ~2 cm inferior to the ribs anterolaterally, and TrA/IAO electrodes were placed ~2 cm superomedial to the anterior superior iliac spine (ASIS) (McGill et al., 1996). A reference electrode was placed over the 12th thoracic spinous process. EMG signals were pre-amplified 1000 times, band pass filtered (20–500 Hz) and notch-filtered at 50 Hz on-line (Neurolog, Digitimer, UK), then sampled at 1000 samples per second with a Power1401 Data Acquisition System using Spike2 software (version 7, Cambridge Electronic Design, UK). Root mean square (RMS) EMG