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Dalhousie Dyspnea and Perceived Exertion Scales: Psychophysical properties in children and adolescents

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ABSTRACT

Children and adolescents vary widely in their perception of, or capacity to rate, sensations during exercise using the Borg scale. We sought to measure sensory-perceptual responses obtained using Dalhousie Dyspnea and Perceived Exertion Scales in 79 pediatric subjects during maximal exercise challenge and to determine the psychophysical function relationship(s). Concurrent validity was assessed by canonical plots of mean ratings on either scale, which showed showing very good correlations for perceived leg exertion *vs* work, and dyspnea *vs* ventilation. Both scales yielded similar results with respect to goodness of fit regardless of whether data was fitted to a power or quadratic function provided a delay term was included. The quadratic model fixed the exponent of the power law at 2 but, unlike a power model, allowed characterization of individual responses that increased and then plateaued. Dalhousie Dyspnea and Perceived Exertion Scales offer an alternative to Borg scale during exercise in pediatric populations.

1. Introduction

Many scales have been employed to measure dyspnea but the most commonly employed is the Borg scale and modifications thereof (Borg, 1962, 1982, 1998). These were developed and studied in adults to rate the distinct but related sensation of perceived exertion. The use of perceptual-sensory scales in children is more problematic. A prerequisite for use of any scale is the subject's ability to seriate – organize objects in order – something that generally reaches an operational stage around 7 years of age (Mareschal and Shultz, 1999). There have been numerous attempts to measure perceived exertion during exercise using a variety of scales in children, reviewed by Eston and Parfitt (2007), who opined that adult-derived methods and applications may not be appropriate for use in pediatric populations. For this reason, other scales have been developed for use in pediatric populations, arguably the most widely used of which is the OMNI scale (Robertson et al., 2000; Utter et al., 2002). Its validation as a measure of dyspnea or perceived exertion has gained traction largely by comparing OMNI ratings with those obtained using the Borg 6-20 RPE scale (Pfeiffer et al., 2002). The children's OMNI scale, despite its appearance of showing a cyclist pedaling uphill, has been used to quantitate *all* perceptual ratings accompanying exertion, *i.e.* overall body (RPE-Overall), legs (RPE-Legs), *and* chest (RPE-Chest).

The Borg scale has undergone evolution since its original conception as the 6-20 RPE scale. Indeed, the respiratory literature and more recent work (Borg and Kaijser, 2006) has explored the psychophysical function obtained using Borg's category ratio (CR-10) scale. This research has shown that ratings for dyspnea and leg effort in adults conform to a power law function: $S = kIa$ where S is the magnitude of the particular sensation of interest (*e.g.* dyspnea), I is the intensity of stimulus (*e.g.* ventilation), k is constant, and a is the exponent, with exponents in adults averaging ~1.6 (Killian et al., 1992). There has been no such analysis among pediatric subjects using any Borg scale or the OMNI scale, but the convergence of developmental understanding at an age when a child can adequately perform spirometry and a maximal exercise test offers the opportunity to conduct psychophysical investigations of dyspnea and perceived exertion in this population.

We designed pictorial scales to measure dyspnea and perceived leg exertion during exercise that involves predominantly work by leg muscles. Scale design has been described (McGrath et al.,

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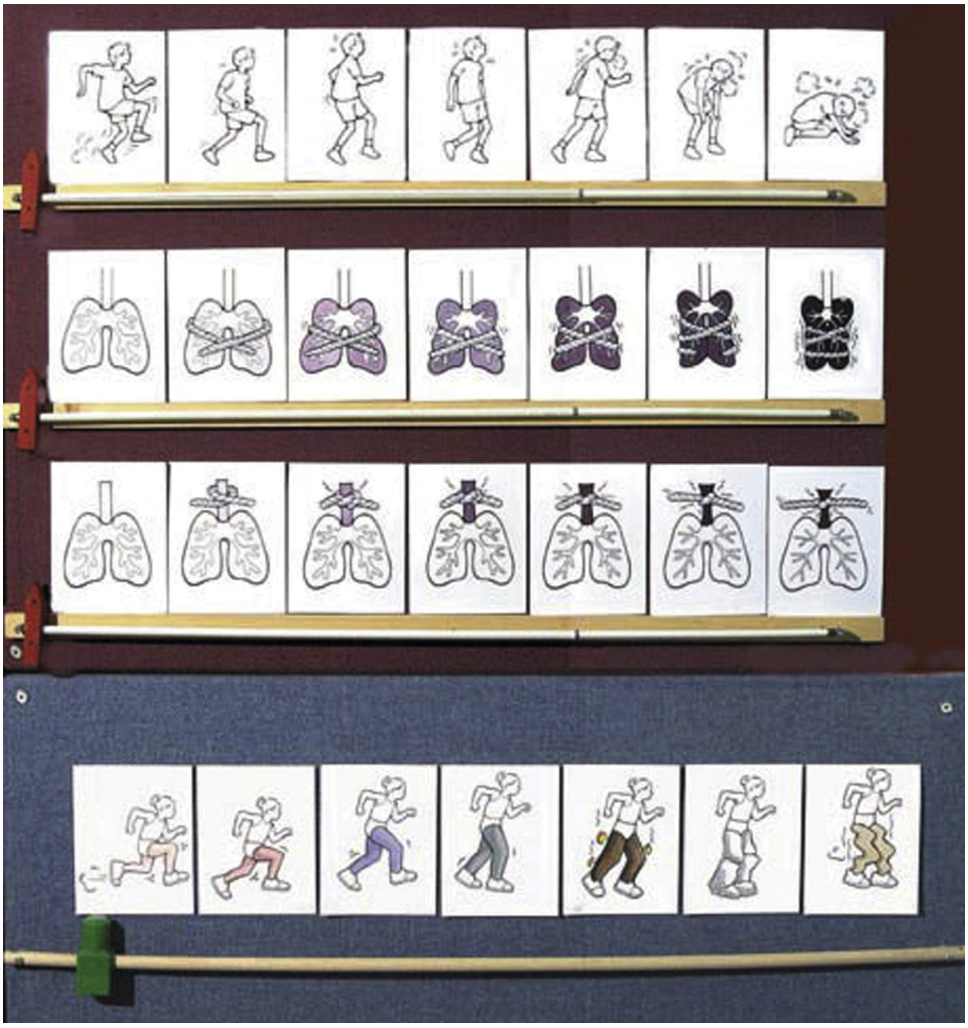

Fig. 1. Dalhousie Dyspnea and Perceived Exertion Scales.

2005) and the scales accurately tracked dyspnea during histamine-induced bronchoconstriction (Pianosi et al., 2006). We recently showed that ratings of perceived exertion obtained using the Borg CR-10 scale in children and adolescents conformed equally well to a quadratic function as to a power function, but goodness of fit was improved by introducing a delay term to account for the lag observed before these sensations were perceived (or reported) to exceed resting levels (Huebner et al., 2014). The aims of the present report were to demonstrate concurrent validity and describe the trajectory of dyspnea and perceived exertion ratings obtained using these pictorial scales in children and adolescents. We hypothesized that Dalhousie Dyspnea and Perceived Exertion Scales ratings would rise with increasing work in a manner or trajectory similar that seen using the Borg CR-10 scale.

2. Participants and methods

2.1. Participants

Children with asthma or cystic fibrosis attending outpatient clinics at IWK Health Centre in Halifax, Canada were invited to participate. Healthy control children were recruited from friends and relatives of hospital personnel, or siblings of the patients. The study received approval from the Research Ethics Board of the IWK Health Centre, and parents or mature minors signed informed consent.

2.2. Procedures

Ventilation and gas exchange were measured breath-by-breath (CPX Plus, WE Collins, Braintree, MA, USA) and averaged every 15 s during each stage of exercise on a cycle ergometer (Collins) test employing step increments of either, 50, 100, or 150 kpm per minute depending on size and age. Increments were chosen to achieve test duration of 6–10 min, until voluntary, symptom-limited, exhaustion.

2.3. Symptom measurement

The Dalhousie Dyspnea and Perceived Exertion Scales consist of a sequence of pictures depicting three, dyspnea constructs: chest tightness, throat closure, and breathing effort; plus an additional pictorial scale to depict leg exertion/fatigue (Fig. 1). The research assistant gave participants an explanation of the pictorial scales at the outset as follows:

> *"The purpose of this test is to see how your breathing feels and how your legs feel during exercise. There are no right or wrong answers. The pictures in front of you show how your breathing might feel, from no difficulty at all, to the most difficulty you can imagine. You might feel this difficulty breathing in your chest or in your throat. Another scale simply asks you to tell us how hard it is to breathe – from nothing at all, to the hardest breathing imaginable. With*